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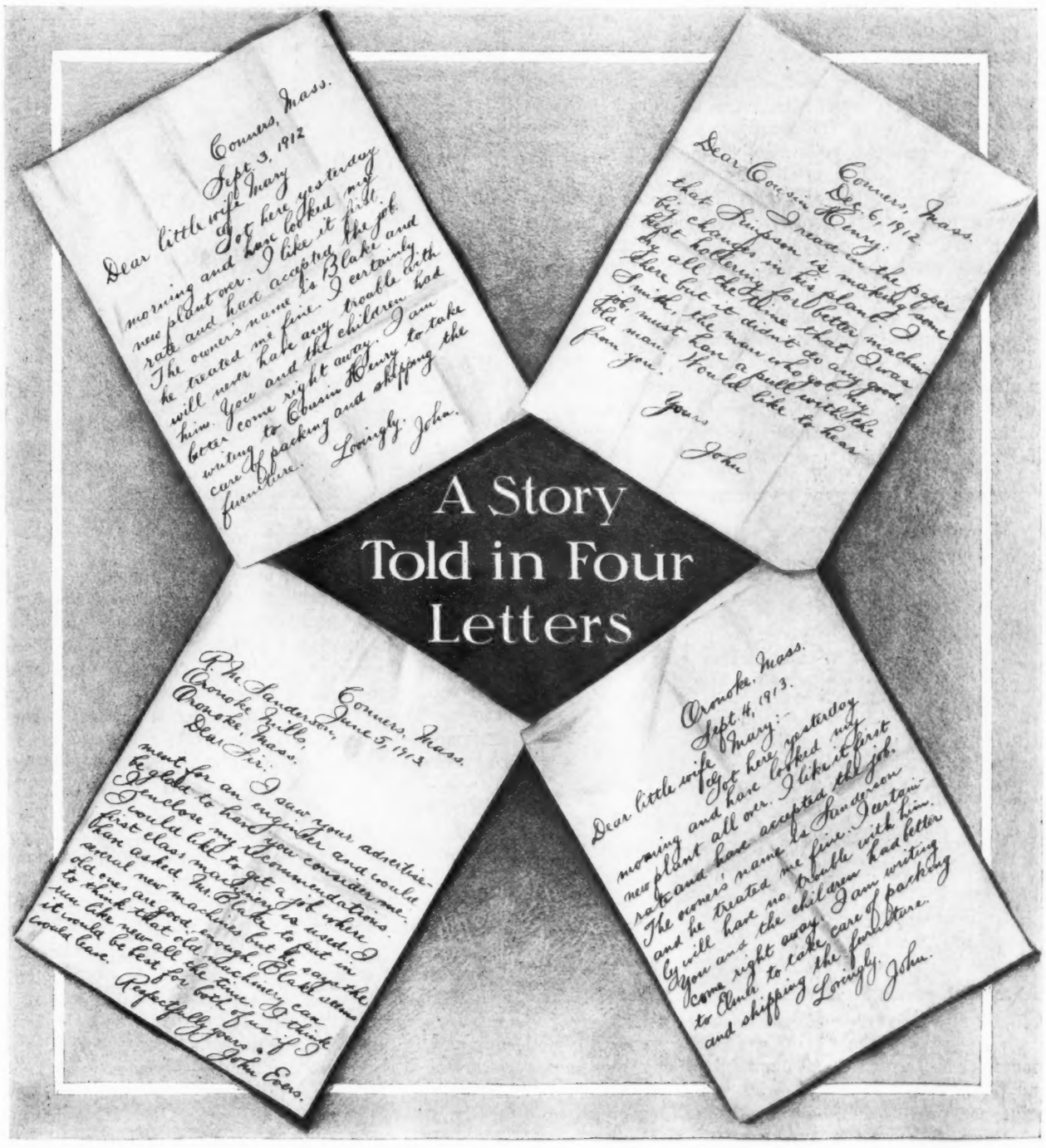


Rochester State Hospital Plant

By Thomas Wilson

SYNOPSIS—A modern power plant having a direct-current capacity of 300 kw. and 1,250 hp. in water-tube boilers. Designed to supply light, power, heating and live steam to the Rochester State Hospital, at Rochester, Minn. In the first year of operation the plant saved $15,000 in fuel over the old plant it replaced.

Recently the Rochester State Hospital for the insane at Rochester, Minn., installed a new power plant which is modern in every respect and is making a large saving in fuel over the old plant which is replaced. The latter consisted of four 200-hp. Galloway boilers operating at 100 lb. pressure and two 250-hp. Hawkes boilers supplying steam at 150 lb. pressure. The boilers were hand-fired. The generating machinery consisted of two 60-kw. units and two 35-kw. generators mounted on the same shaft and driven by a vertical compound engine.

The new plant was laid out to furnish heat, light, power and live steam for the laundry and kitchens belonging to the institution, which consists of ten buildings ranging in height from one to four stories. The power-plant building, which is made up of concrete and steel, is 88x88 ft. in plan; the height of the boiler-room ceiling is 31 ft. 6 in. and of the engine room 24 ft.; from the boiler-room floor to the top of the coal-bunker monitor, the elevation is 63 ft. The building is fireproof throughout, the engine-

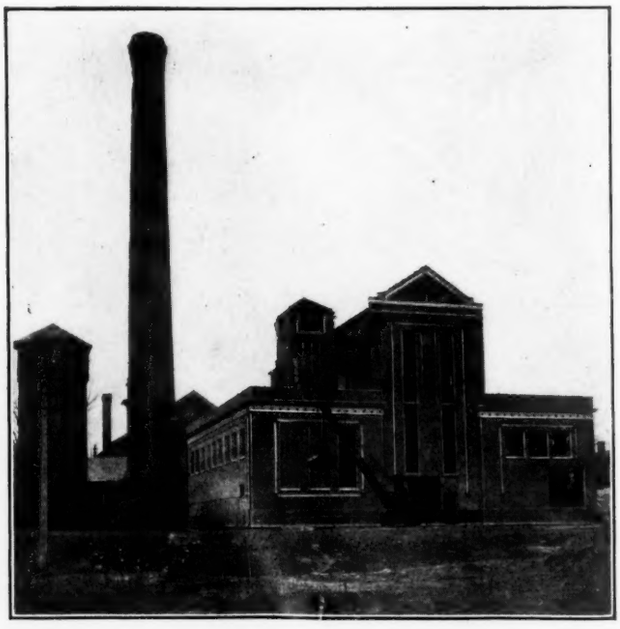


FIG. 1. POWER PLANT, ROCHESTER STATE HOSPITAL

room floor is of gray tile and the wainscoting of the engine and pump rooms is enamel brick. Toilets and shower baths are provided in both engine and boiler rooms. Some idea of the exterior appearance of the building may be gathered from Fig. 1.

As the nature of the institution is such that a shutdown in extreme weather, if only for a few hours, might bring disastrous results, much of the equipment is arranged in duplicate. The boiler plant is of such capacity that there is always one boiler in reserve. The generating equipment is in duplicate, and the same applies to the vacuum, boiler-feed and domestic-water pumps, the stoker fans, the boiler-feed piping and the high-pressure steam headers.

Fig. 2 is a view in the boiler room, and Figs. 3 and 4 show the general layout of the plant. The steam-generat-

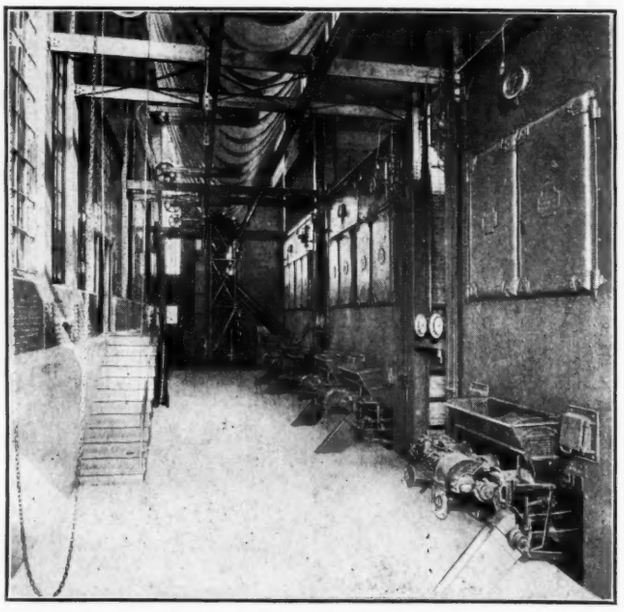


FIG. 2. A VIEW IN THE BOILER ROOM

ing equipment consists of five 250-hp. water-tube boilers, with tubes 20 ft. long. The settings are of the four-pass type, the gases passing downward through an underground concrete flue to a brick stack 7 ft. in diameter and 141 ft. high, located outside the building. The headroom from the boiler-room floor to the bottom of the front header is 10 ft. The settings are arranged for steel jackets, which are to be placed later. Each boiler is equipped with a nonreturn automatic stop valve and twin pop safety valves—one set at 145 lb. and the other at 150 lb. The former has a vent pipe leading through the roof, while the other is piped to blow into the boiler room. High- and low-water alarms, feed-water regulators and steam-flow meters are also part of the equipment.

There is a double system of feed-water piping—one for hot water and the other for cold water, to be used in washing the boilers—but the two lines are so connected that either can be used. Underfeed stokers of the latest type, with three retorts per boiler, are installed. Forced draft is supplied by duplicate fan units driven by vertical engines. Either fan has sufficient capacity for all the stokers at heavy overloads. Under the boiler-room floor are two tunnels—one for the air to the furnaces and one for the shaft from which the stokers are chain-driven. This shaft is driven by the fan engines, each of which has a clutch so that it can be cut in or out as desired. Pressure regulators control the speed of the fan and stoker engines so that the proportion of fuel and air is maintained constant at all loads.

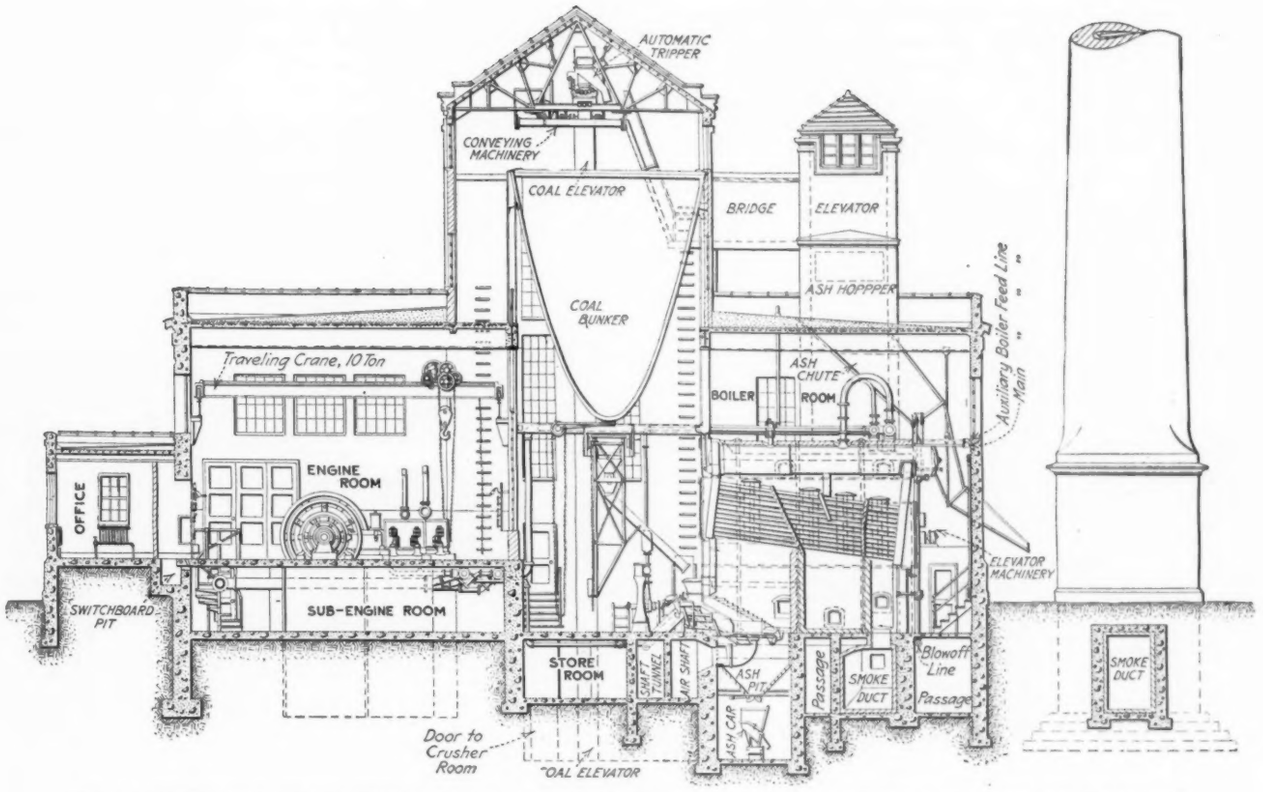


FIG. 3. SECTIONAL ELEVATION THROUGH THE POWER PLANT AT THE ROCHESTER STATE HOSPITAL

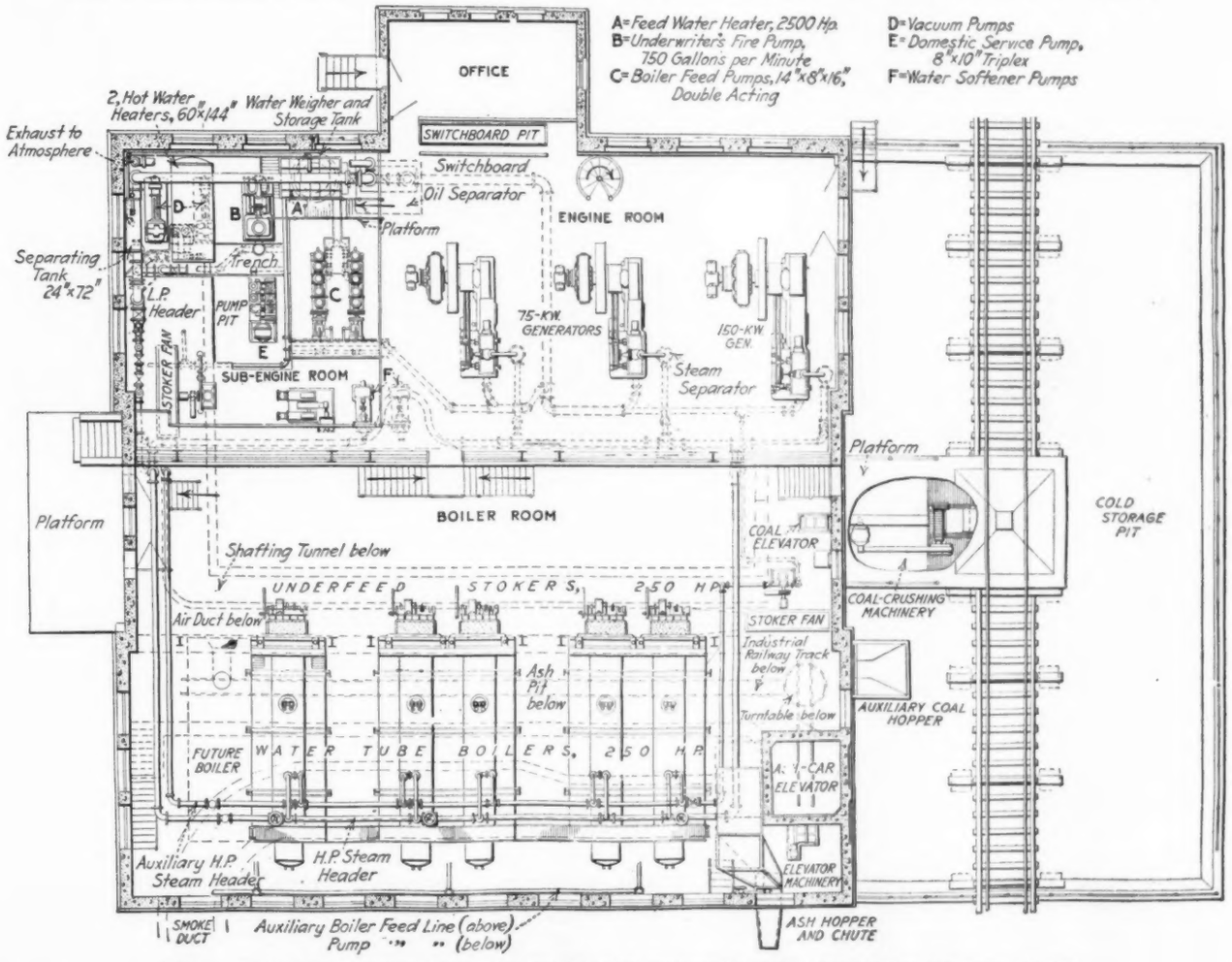


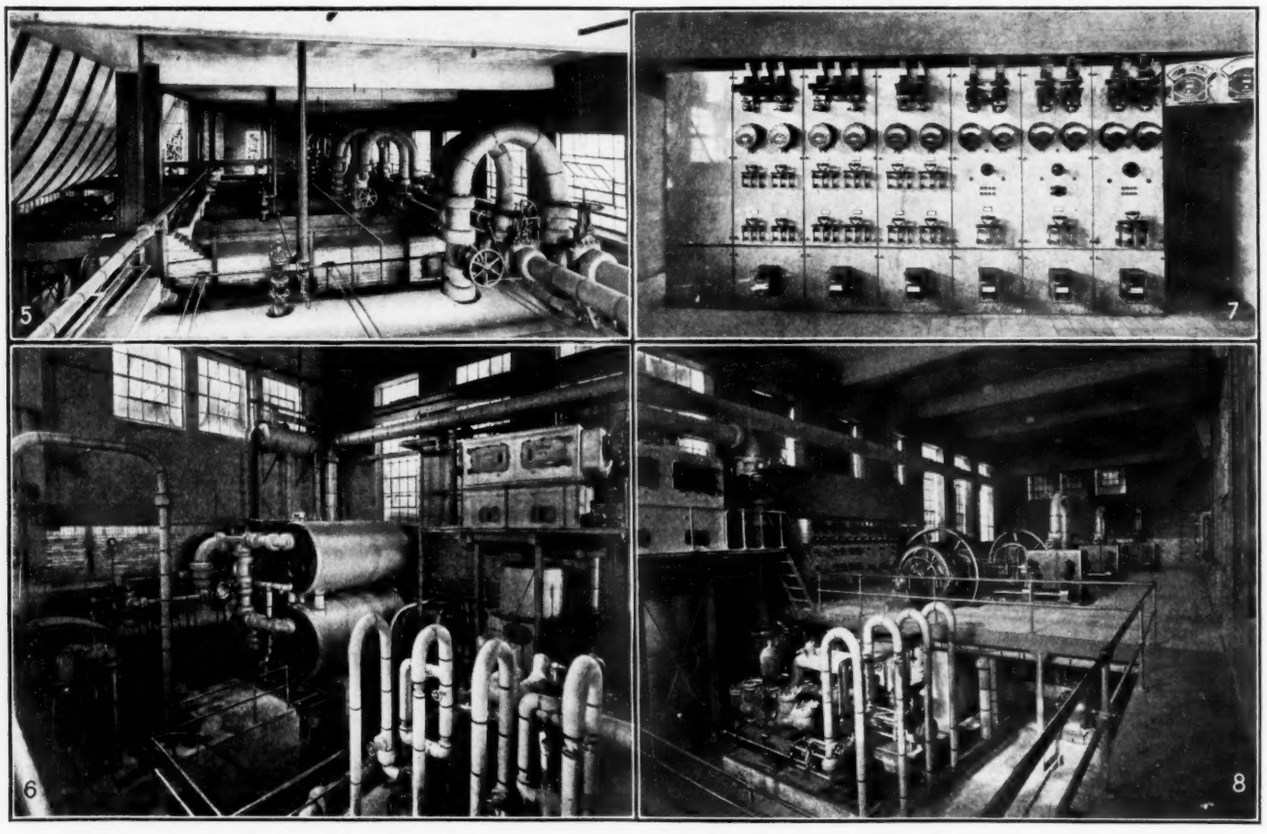
FIG. 4. PLAN OF ENGINE AND BOILER ROOMS, SHOWING ARRANGEMENT OF THE UNITS

Coal is received in railway cars on a siding which comes directly over a receiving hopper. From this hopper the coal can be delivered directly to a bucket elevator through a short conveyor, or it may be run first through a crusher and then to the bucket elevator, which delivers to a belt conveyor running over the 750-ton concrete bunker. The belt conveyor has an automatic tripper so that the coal may be delivered at any point in the bunker or may be distributed the whole length of the bunker. On its way to the hoppers of the stokers, the coal passes through weighing lorries, as indicated in Fig. 3. The gates at the bottom of the bunker are controlled by chains within easy reach of the boiler-room floor. As shown in Fig. 4, a 1,200-ton concrete storage pit is provided outside the building. From this pit the coal is transferred to the track hopper by an electric-locomotive crane with a bucket holding 27 cu.ft. The coal-handling equipment has a capacity of 20 tons per hr.

From the pit under each furnace the ashes are dropped into industrial cars, which are pushed upon an elevator and raised to a special hopper discharging the ashes outside of the building, to be carted away later for road building on the premises.

Water for the institution is obtained from wells, four of them being just outside of the power house. These wells are about 40 ft. deep and equipped with screens. All are connected to a suction line leading into the power house to a fire underwriters' pump and a single-acting triplex motor-driven pump used for domestic service. The water is stored in a reservoir holding 1,250,000 gal., which is on top of a hill, about one-half mile from the plant. It is divided into two parts—one for raw and the other for soft water. All cold water used by the institution, except as noted hereafter, is raw water, as pumped from the wells. The hot water used throughout the building, the cold water in the laundry and the water for the boilers is softened; after it has been treated, it is pumped to the reservoir by a 3-in. motor-driven centrifugal pump. The total daily water consumption during the summer months is about 250,000 gal.

All heating returns are delivered by either of two 10&16x18-in. vacuum pumps to the separating tank. From here the water flows to an open feed-water heater and then to outside end-packed, pot-valve pattern boiler-feed pumps. The piping is arranged so that the water may be taken through a water weigher. One vacuum or one feed pump is of sufficient capacity for the entire installation, so that the units are arranged in duplicate. The feed to the boilers is controlled by continuous feed regulators.



FIGS. 5 TO 8—GENERAL VIEWS OF THE ROCHESTER STATE HOSPITAL POWER PLANT

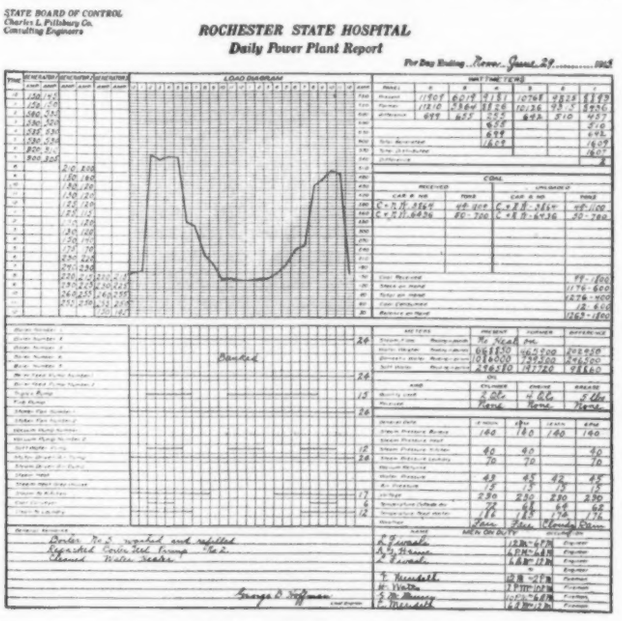
Fig. 5—Piping at top of boilers. Fig. 6—Sub-basement in engine room. Fig. 7—Seven-panel blue Vermont-marble switchboard. Fig. 8—Engine room

One 150-kw. and two 75-kw. generating units handle the lighting and power load. The generators are of the three-wire direct-current interpole type and are directly connected to gridiron valve, flywheel-governor, side-crank, self-oiling, inclosed-type engines. The larger engine has a cylinder measuring 16x24 in. and a speed of 160 r.p.m. The smaller engines are 12x18-in. and their speed is 200 r.p.m. Current is generated at 125-250 volts. The controlling mechanism and instruments are on a seven-panel blue Vermont-marble switchboard. There is a panel for each generator, three feeder panels and one blank panel. All electric feeders are taken from the rear of the board

underground to the tunnels connecting with the various buildings. The power house has two complete systems of wiring—one for lighting and one for power, both run in iron conduits. On the opposite side of the room from the switchboard is a gage board containing a number of indicating and recording gages, including a high-pressure header gage, an auxiliary header gage, a high-pressure recording gage a low-pressure recording gage, a low-pressure gage, a combination water-pressure and altitude gage, an air-pressure gage, a vacuum gage on the returns and a clock mounted on top of the board and connected to the clock system of the institution.

The arrangement of the steam and exhaust piping is shown in Figs. 3 and 4. There are duplicate headers, and either may be used to supply the generating units. The piping from the boilers to the header is shown in Fig. 5. All pipes carrying high-pressure steam and feed water are extra strong and the fittings and valves extra heavy. The pipes carrying low-pressure steam and water, other than feed water, are standard weight, as are the fittings and valves, the last-named being designed for 125 lb. pressure. All piping carrying high-pressure, 4-in. and over in diameter, is covered with 85-per cent. magnesia, 2 in. thick. The smaller sizes and the pipes carrying low-pressure steam are covered with the standard 1½-in. thickness of 85-per cent. magnesia.

Exhaust steam is used for heating water in the summer and in the winter for heating the building. As the amount of exhaust is inadequate except in very mild weather, live steam is used and the pressure reduced through two pressure-reducing valves—one lowering the boiler pressure of 140 lb. to 70 lb. and the second from 70 lb. to the required pressure, which varies with the weather. A second set of reducing valves on a separate line of piping reduces the pressure of the steam for the laundry


STATE BOARD OF CONTROL
Charles L. Pillsbury Co.
Consulting Engineers

ROCHESTER STATE HOSPITAL
Daily Power Plant Report

For Day Ending ..Noon, June 29 1915

FIG. 9. DAILY POWER-PLANT REPORT

PRINCIPAL EQUIPMENT OF ROCHESTER STATE HOSPITAL PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	Water-tube	250-hp	Generate steam	140 lb. pressure, stokers, forced draft	S. Freeman & Sons Mfg. Co.
5	Stokers	Underfeed	Three-retort	Serve boilers	Chain-driven from stoker shaft	(Taylor) American Engineering Co.
2	Fans	Sirocco	140-in	Forced draft to stokers	Driven by vertical engines	American Blower Co.
2	Engines	Simple vertical	9x8-in	Drive fans and stokers	140 lb. steam; controlled by Mason governor	American Blower Co.
5	Valves	Non-return automatic stop	6-in	In boiler leads		Lunkenheimer Co.
10	Safety valves	Twin pop	3½-in	On boilers	One set at 145 lb.; other at 150 lb.	Lunkenheimer Co.
5	Alarms	High and low water		On boilers		Reliance Gauge Column Co.
5	Regulators	Mechanical		On boilers		The "S-C" Regulator Co.
6	Flow meters	Type F. S. 4		Boiler steam and exhaust steam for heating		General Electric Co.
1	Stack	Brick	7 ft. diam., 141 ft. high	Serve boilers		General contractor
1	Bunker	Concrete	750-ton	Store coal		Brown Hoisting Machinery Co.
1	Elevator	Bucket		Raise coal to top of monitor	Driven by 7½-hp. motor	Robins Conveying Belt Co.
2	Conveyors	Belt	14-in	Coal-handling system	Driven by 5-hp. motor; capacity 20 tons per hr.	Robins Conveying Belt Co.
1	Crusher	Roll	20-ton	Crush coal	Driven by 20-hp. motor	Robins Conveying Belt Co.
1	Crane	Electric locomotive	Bucket 27 cu.ft.	Transfer coal from storage to track hopper	Travel motor, 28 hp.; hoist motor, 28 hp.	Brown Hoisting Machinery Co.
2	Cars	Industrial	1-ton	Transfer ashes to storage bin		Minneapolis Steel & Machinery Co.
1	Elevator	Electrical	3,000-lb	Raise ash cars to storage bin	Driven by hp. motor	Gus Lagerquist
1	Engine	Gridiron valve, side-crank	16x24-in	Main generating unit	140 lb. steam, 160 r.p.m.	McIntosh & Seymour Corp.
1	Generator	Three-wire d.-c interpole	150-kw	Main generating unit	250 v., 160 r.p.m., direct-connected	(Western Electric) General Electric Co.
2	Engines	Gridiron-valve, side-crank	12x18-in	Main generating unit	140 lb. steam, 200 r.p.m.	McIntosh & Seymour Corp.
2	Generators	Three-wire, d.-c., interpole	75-kw	Main generating unit	2,500, 200 r.p.m., direct-connected	(Western Electric) General Electric Co.
1	Switchboard	Blue Vermont marble	7-panel	Control and distribution	Western ammeter and voltmeter, I. T. E. circuit-breakers, Columbia wattmeters.	Northwestern Electrical & Equipment Co.
1	Heater	Open		Feed water	Exhaust steam	(Blake - Knowles) International Steam Pump Co.
1	Water weigher	Kennicott	50,000-lb	Weigh feed water		The Kennicott Co.
2	Heaters	Closed		Service heaters		The Sims Co.
1	Water softener	Cold-process	15,000 gal. per hr.	Service and boiler feed		Russell
2	Weighing lorries	Traveling	1,000 lb.	Weigh coal to boilers		Robins Conveying Belt Co.
2	Pumps	Burnham simplex	16x8x14-in	Boiler feeders	140 lb. steam, controlled by S. C. Governors	Union Steam Pump Co.
2	Pumps	Vacuum	10x16x18-in	Heating system	140 lb. steam	(Blake - Knowles) International Steam Pump Co.
1	Pump	Underwriters	16x9x12-in	Fire pump	140 lb. steam, Fisher governor	(Blake - Knowles) International Steam Pump Co.
1	Pump	Triplex	8x10-in	Domestic service	Motor-driven, 20 hp.	Platt Iron Works
1	Pump	Centrifugal	3-in	Water from softener to reservoir	Motor-driven, 20 hp.	Jeanesville Iron Works Co.
1	Air compressor	Duplex	6x8-in	Air to sewerage ejector	Motor-driven, 15 hp.	Laidlaw-Dunn-Gordon
2	Air compressors	Locomotive type	9½-in	Air to sewerage ejector	Steam 140 lb.	Westinghouse Air Brake Co.
1	Crane	Hand-operated	10-ton	Spans engine room		Whiting Foundry Equipment Co.
14	Traps	Steam, float	1 to 1½-in	Drain steam lines	High and low pressure	V. D. Anderson Co.
1	Trap	Tilting	1½-in	Condensation from service heaters	Low pressure	Crane Co.
3	Lubricators	Force-feed	2-qt., single-feed	On main engines		Richardson-Phenix Co.
7	Lubricators	Force-feed	1-qt., single-feed	On pumps and stoker engines		Manzel Bros. Co.

On high-pressure steam and feed-water lines, Lunkenheimer extra heavy valves; on low-pressure steam and water lines, Crane standard-weight valves. Durabla gaskets in high-pressure lines and Rainbow in standard lines. Kieley pressure reducing valves.

and kitchens and for various sterilizing rooms and other purposes.

Two isolated buildings have a steam line carrying 60 lb. pressure, which is farther reduced at the building. The returns from these buildings are pumped back to the power house. Steam at low pressure, used for heating, is measured by a steam-flow meter.

From a daily plant report, such as is shown in Fig. 9, it is easy to compute the cost of operation. This has been done carefully, and the results for the first year show a reduction of $15,000 in the fuel bill. This is just 10 per cent. of the total cost of the new plant, which amounted to $150,000.

From tests that were run at the time of installation, the efficiency of the boiler, furnace and stoker was found to be 75 per cent. In a recent test the average evaporation per pound of coal as fired was 7.84 lb., or 8.33 lb. from and at 212 deg. This test was conducted on the regular daily load on one boiler under an average load of 84.8 per cent. of rating. The coal used was Franklin County, Illinois, 1½-in. screenings, with the following analysis: Moisture, 6.7 per cent.; volatile matter, 37.5 per cent.; fixed carbon, 51.9 per cent.; ash, 10.6 per cent.; B.t.u. as delivered, 11,850.

The plant was designed by the Charles L. Pillsbury Co., consulting engineer, of St. Paul and Minneapolis, Minn., and the installation was supervised by its superintendent of construction, Charles Foster. George B. Hoffman is chief engineer of the power plant, and Dr. Arthur F. Kilbourne is superintendent of the hospital.

Renewing Economizer Tubes

By Charles H. Bromley

SYNOPSIS—The tubes are of cast iron and make metal-to-metal joints with the headers. They are pulled out of the headers with a drawbar and lifted with a special tool. In the Green economizer the tops of renewal tubes are rusted in, usually with sal ammoniac and iron filings.

[Elsewhere in this issue is an editorial relative to the renewal of economizer tubes in remarkably quick time. No one seems to know how the man referred to does it, and he will not tell nor will he do the work if watched. If there really is some worth-while short cut *Power* is going to find out or, with the help of its many thousand readers, publish the essentials of a method just as good and as quick. See the editorial, page 189. The usual methods of renewing such tubes are described herewith. Have you a better and quicker way? If so, describe it in *Power*, as your experience will be appreciated.—Editor.]

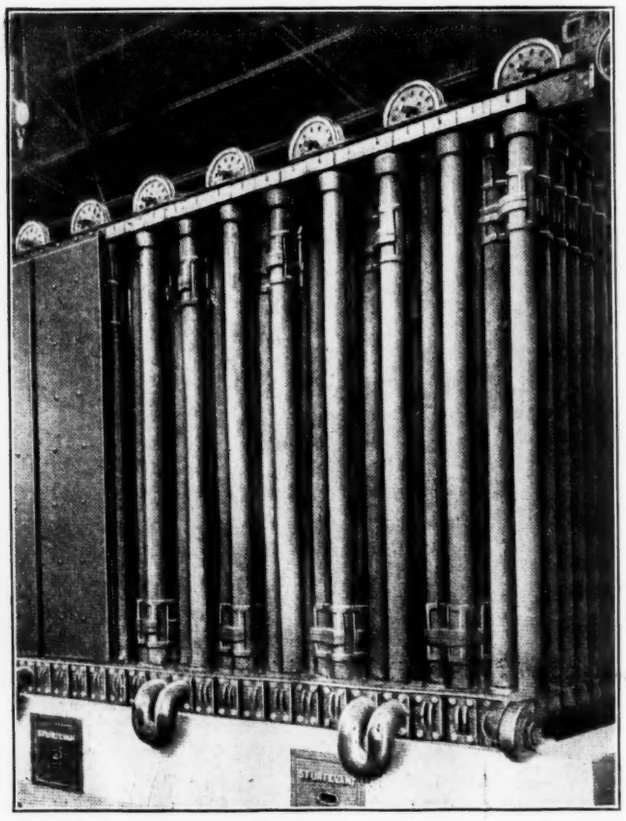


FIG. 1. STURTEVANT ECONOMIZER ASSEMBLED

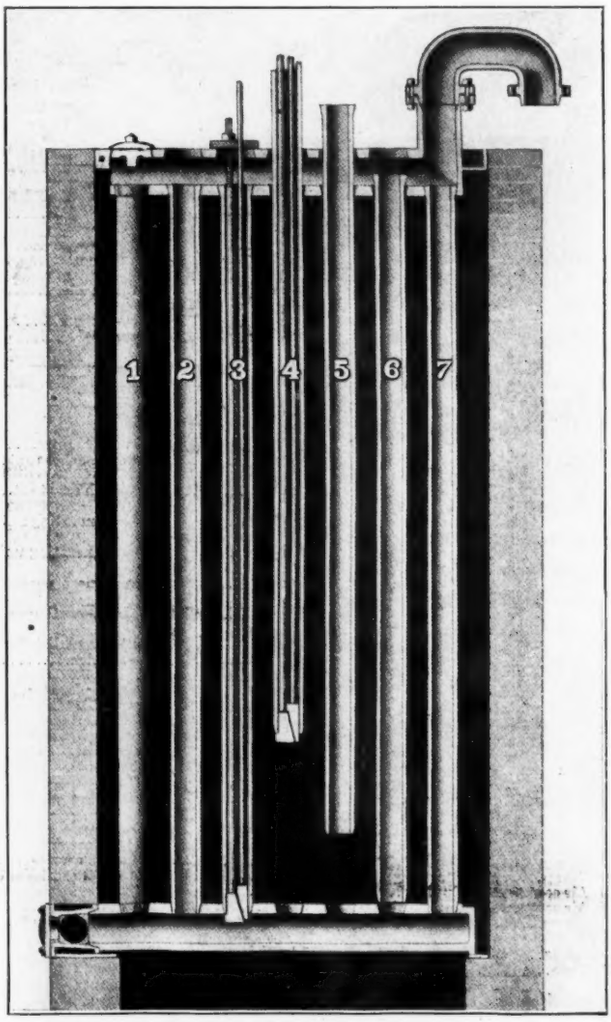


FIG. 2. SHOWING APPLICATION OF DRAW BAR

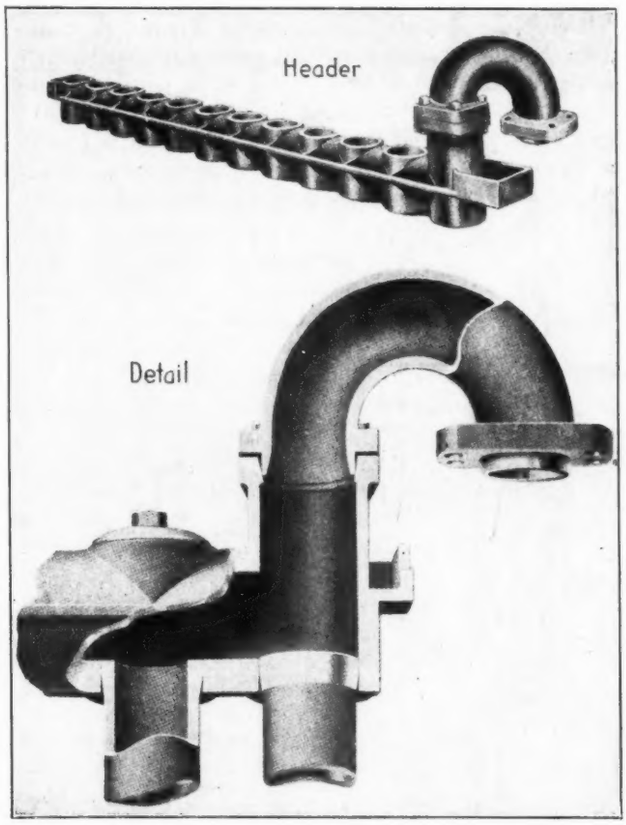


FIG. 3. DETAILS OF STURTEVANT ECONOMIZER

Economizers are usually made up in sections, each section having a top and a bottom header, box, or manifold, as they are variously called. Connecting the top to the bottom header are tubes of cast iron, the fit being a tapering and pressed one. The tubes are, roughly, 4½ in. diameter and 9 to 10 ft. long, placed vertically between headers, the headers being bolted together to form a long bank of tubes.

Part of an assembled Sturtevant economizer is shown in Fig. 1. The method of removing a tube is shown in Fig. 2. Notice that the ends of the tube are tapered, the top end tapering out and the bottom end tapering in. The top cap is removed from the header, the long drawrods with the wedges at the bottom ends are inserted, and the nut on the rod at the left is screwed down, withdrawing the tube. The new tube is inserted and hammered tight. A view of the complete header, also a detail, are shown in Fig. 3. The cap which stops the tube hole

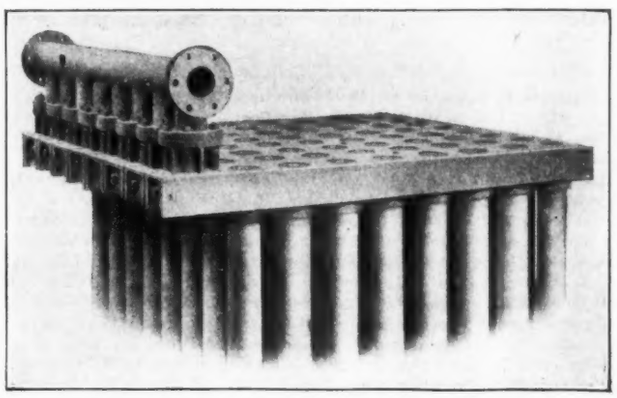


FIG. 4. TOP OF GREEN ECONOMIZER

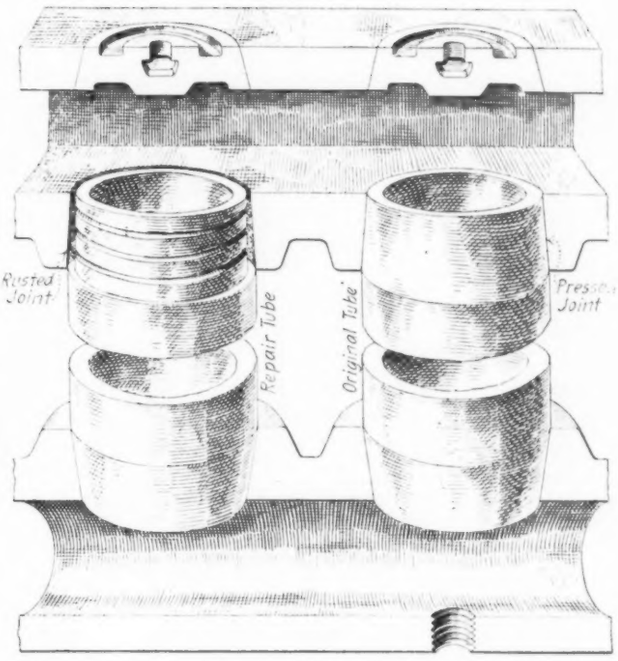


FIG. 5. PART SECTION OF HEADERS, SHOWING ONE RENEWED TUBE AND ONE ORIGINAL TUBE

in the top of the header is much like the cap construction of a Babcock & Wilcox boiler, with which nearly all are familiar. No gaskets are used in the economizer, all joints being metal to metal even for both ends of renewed tubes.

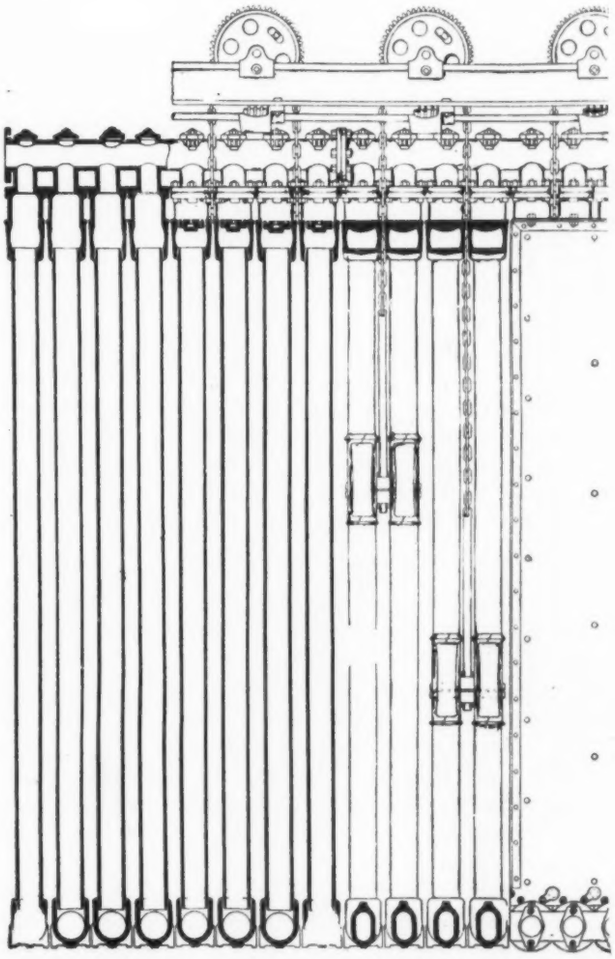


FIG. 6. SECTION ASSEMBLED GREEN ECONOMIZER

The top portion of the Green economizer is shown in Fig. 4, and a longitudinal section of a header, or top box as it is called, with the tubes and two of the "internal lids," or caps, in place, is shown in Fig. 5. These caps are drawn tight by means of a yoke and key-bolt and held tight by friction and the pressure in the economizer. The bottom header is an ordinary manifold. A part

Of course it is understood that any attempt to standardize the time of taking out and putting in, particularly taking out, economizer tubes must allow for local conditions. The action of the water may soften all of the tubes or only some of them, and when a pull is put on the drawbar the latter will crush through the tube. Those familiar with metal-to-metal joints appreciate that some

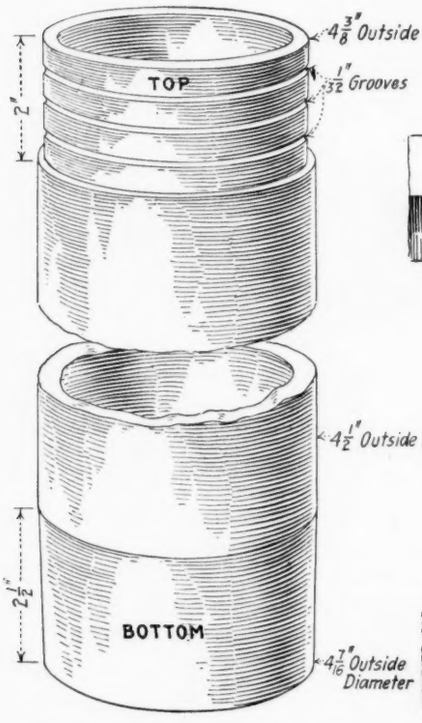


FIG. 7. REPAIR TUBE FOR GREEN ECONOMIZER

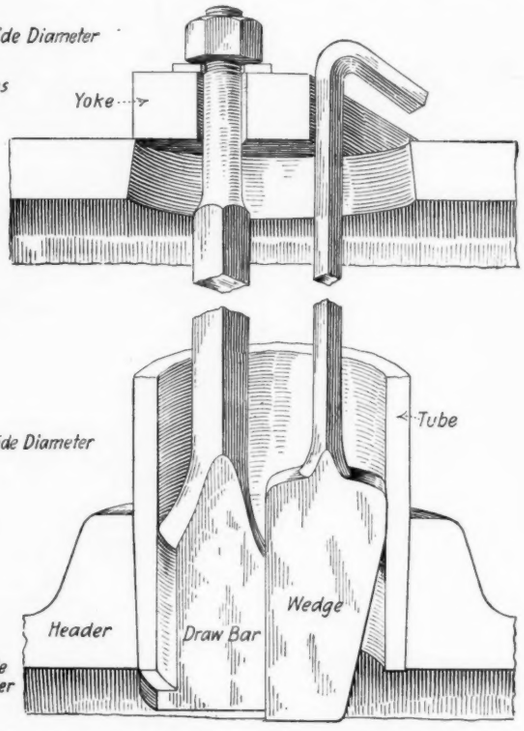


FIG. 8. DRAW BAR AND WEDGE USED TO PULL TUBES FROM GREEN ECONOMIZER

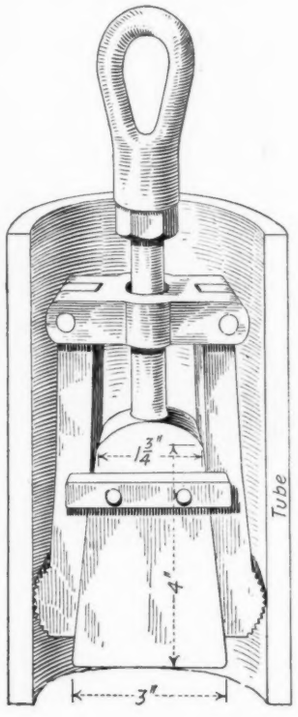


FIG. 9. TOOL FOR LIFTING ECONOMIZER TUBES

sectional view of the assembled economizer is shown in Fig. 6. Notice that the tubes taper from the outside in at both ends. To get the standard tube in would, therefore, require the removal of one header, say the top one, the tube being driven to a fit in the bottom header and the top header pressed on. To avoid all this, a special tube, Fig. 7, called a repair tube, is used for replacing one taken out. This tube has the taper at the bottom only. It is put through the hole in the top header and the bottom of the tube driven "home" in the tapered outlet in the bottom header. The top of the tube is a loose fit in the top hole, and this end is made tight by a rust joint, made usually with iron filings and sal ammoniac.

In the Green economizer the original tubes, or those that come with the economizer as it leaves the shop, taper toward the center at both ends. The tube cannot, therefore, be withdrawn without breaking or slotting it to allow it to squeeze through the tube holes. As stated, the repair tubes are tapered only at one end, the bottom; the top is straight and rusted in.

These repair tubes are pulled out with a drawbar and wedge, as shown in Fig. 8. The drawbar has a projection which catches one side of the bottom end of the tube. Care must be taken not to catch the header with the projection—screwing down on the drawbar nut might crush the header, necessitating renewing or blanking it. When the tube is loosened, the tool, Fig. 9, makes easy its withdrawal. The sketch explains itself.

joints break easily, while others require considerable "coaxing." In one large plant with which I am familiar, three men are usually assigned to the job of tube renewals, and the time required to take out and put a tube in the Green economizer is 3½ hr. Of course one must be sure that the surfaces of the joints are clean.

Safety of Boiler Operation in Prussia is on the increase, according to some interesting statistical information recently reported. The number of explosions due to various causes is gradually decreasing; moreover, while, for example, the number of accidents due to careless attendance has increased during the last few years, the number of explosions from this cause has decreased, which would indicate that boilers are being so built that they can withstand a certain amount of carelessness in handling without actually going to pieces.

Experts to Approve Boiler Construction—It is believed that there exists the same necessity for the creation of a corps of boiler experts in the office of the Supervising Inspector General to approve boiler construction that exists for the creation of a corps of experts to approve hull construction. There should be as much uniformity as possible in the matter of boiler construction and inspection, and satisfactory uniformity cannot be obtained until such a corps of experts is established in the central office. Anyone familiar with boiler-repair work knows that the use of oxyacetylene welding is being rapidly extended, and this work should be carefully followed up by the inspectors. It is not so much that there is danger in welding under certain conditions as that the workman who does the welding is not qualified to do it, and there should be a sufficiently large force of boiler inspectors to keep in touch with this work.—From annual report of the Supervising Inspector General, Steamboat Inspection Service.

Air in Compression and Expansion

By C. K. Bennett

In the compression of air all the work done is converted into heat and shows itself in the temperature of the compressed air. The accompanying chart[1] is based on air at atmospheric pressure and an initial temperature of 60 deg. The curves marked 1.41, 1.35 and 1.25 are plotted for the given exponents representing the ratio $Cp \div Cv = K$, and express the ratio of specific heat at constant pressure and constant volume.

When air is compressed adiabatically, all of the heat resulting from the compression is retained in it and the exponent of the curve is 1.41. For example: Adiabatic compression from 14.7 lb. absolute and 60 deg. F. to 200 lb. absolute. It will be seen by reading to the left from where the 200-lb. vertical line intersects the curve marked 1.41, that the temperature of the air after the compression is 651 deg., and by reading from the same point radially to the volume at the top, it will be found that one cu.ft. of free air when compressed under the conditions mentioned will equal 0.157 cu.ft. By reading again from the same point horizontally to the right (200 lb. on the 1.41 curve) it will be seen that there will be 64,200 B.t.u. given up to the air per hour, when compressing 100 cu.ft. of free air per minute.

Cooling the air during compression by the injection of water, radiation, etc., alters the value of the exponent curves K and therefore various curves of exponents are plotted, by means of which the temperatures, volumes and B.t.u. may be found for any condition.

A compression curve with an exponent of 1.25 is the best result that was obtained at Quai De La Gare, Paris, in a single-cylinder compressor cooled with a very fine spray of water.

In addition to the volume and temperature, the theoretical horsepower required to compress the air may be found from the B.t.u. per hour for compressing 100 cu.ft. per min. to the desired pressure, and taking the same relative part of these B.t.u. as the number of cu.ft. that is desired to be compressed is of 100, thus getting the correct number of B.t.u. for the given amount of air at the given pressure. The B.t.u. found when divided by 2,545 will give the theoretical horsepower required; to which should be added the allowance for friction, clearance, etc., to correspond to the compressor under consideration. The final result will give the horsepower required to drive the compressor under the various conditions set forth.

The volume of 1 cu.ft. of free air after compression may be read directly, and by plotting all factors or values from the one curve, when the pressure line is followed up to the curve representing the exponent of compression and a pencil is held at that point, all factors can be read directly; that is, temperature, volume, B.t.u. (which by the way is a decided and valuable addition to the curve) and the horsepower required may be determined. The heat available for heating from the compressed-air transmission pipes can also be readily determined.

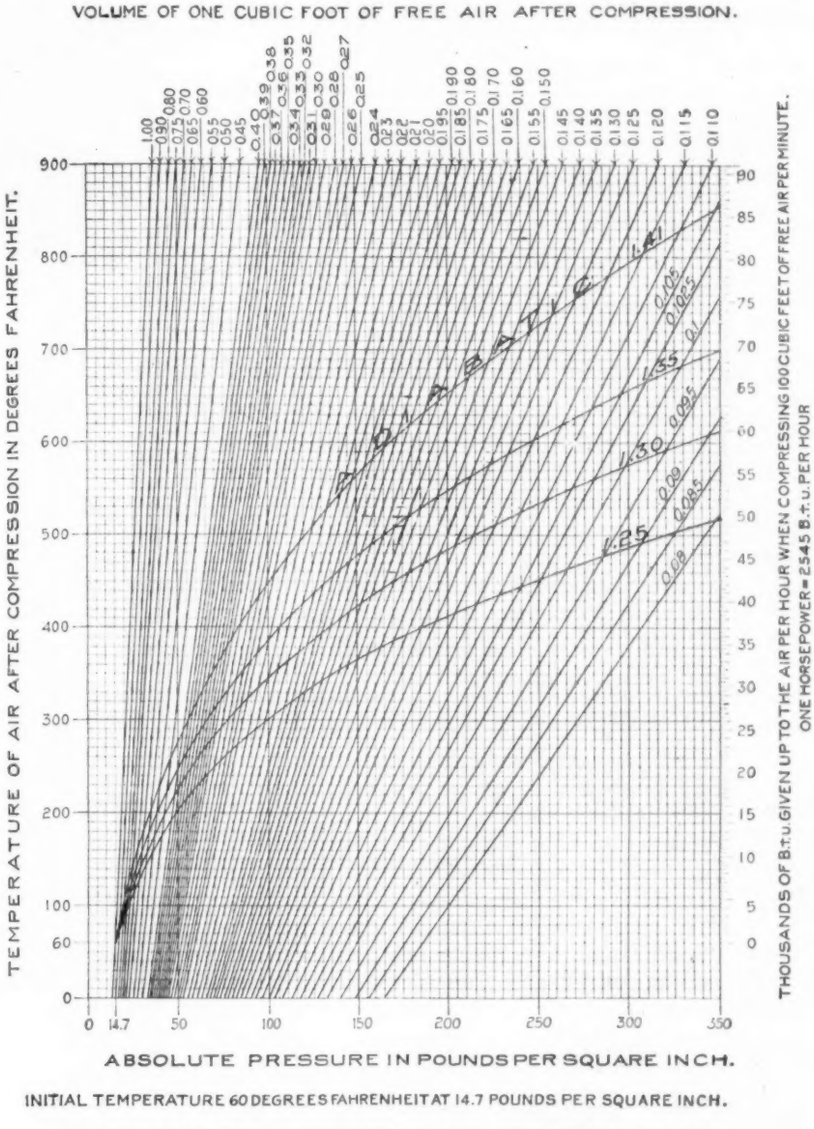

VOLUME OF ONE CUBIC FOOT OF FREE AIR AFTER COMPRESSION.
TEMPERATURE OF AIR AFTER COMPRESSION IN DEGREES FAHRENHEIT.
THOUSANDS OF B.t.u. GIVEN UP TO THE AIR PER HOUR WHEN COMPRESSING 100 CUBIC FEET OF FREE AIR PER MINUTE. ONE HORSEPOWER = 2545 B.t.u. PER HOUR
ADIABATIC
1.41
1.35
1.30
1.25
ABSOLUTE PRESSURE IN POUNDS PER SQUARE INCH.
INITIAL TEMPERATURE 60 DEGREES FAHRENHEIT AT 14.7 POUNDS PER SQUARE INCH.

DIAGRAM FOR COMPRESSION AND EXPANSION OF AIR

[1] Copies of this chart, 17x20 in., may be secured from C. K. Bennett, 1949 East Monmouth St., Philadelphia, Penn., for $1 each.

Rosin Oil is Cheap and its specific gravity high, therefore it is sometimes used to adulterate lubricating oil. When it has been considerably refined, it can be added in large quantities without much chance of detection except by a chemist; but since it has no lubricating qualities, the action of the mixture will be unsatisfactory.

The Law of Fluid Motion is that the force required to shear a layer of fluid, of a given area of the element in plane of shear, and thickness, normal to the plane of shear, is directly proportional to the relative velocity (surface speed of journal) of the two surfaces and to the area, and inversely to the thickness, of the fluid.

Friction Loss Through Check Valve and Condenser

In water-works or power plants, where large quantities of water are pumped, the importance of keeping the friction loss in piping, condensers, check valves and venturi meters at a minimum is not always given the serious consideration it merits. The following tests and computations were made with the idea of determining the friction losses and their resultant cost through a water-works type condenser, a 36-in. check valve and a 36-in. venturi meter, which are on the discharge of the 30,000,000-gal. De Laval pumping unit at Kirtland Station, Cleveland, Ohio, described in the Dec. 14, 1915 issue.

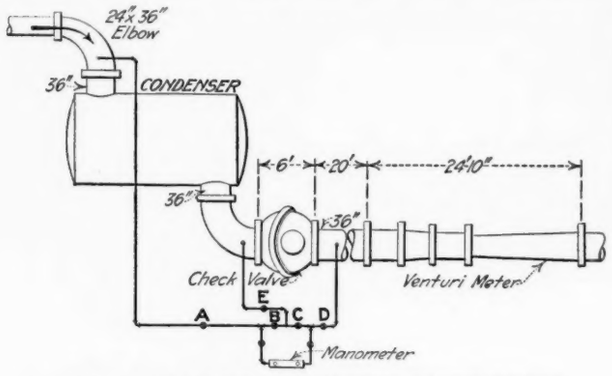


FIG. 1. PLAN OF MANOMETER CONNECTIONS

TABLE 1. 36-IN. ROE STEPHENS SWING CHECK VALVE

Angle of valve plate	18.5 deg.
Diameter of valve plate	74 in.
Distance between faces of inlet and outlet flanges	6 ft.
Number of valves	11
Diameter of valve openings	12 in.
Approximate weight of each valve	40 lb.
Pressure required to start water through valve (feet of water)	0.3 lb.
Area of each valve	0.7854 sq.ft.
Total area of valves	8.639 sq.ft.
Area of 36-in. pipe	7.069 sq.ft.
Ratio of area of check valves to 36-in. pipe and ratio of velocities	1—81.9

TABLE 2. CONDENSER—WATER-WORKS TYPE

Inside diameter of case	62.5 in.
Length of case (inside)	10 ft. 9 in.
Number and diameter of tubes	634—1 $\frac{3}{16}$ o.d.
Total area of tubes (outside)	2,120 sq.ft.
Diameter of water inlet and outlet	36 in.
Cross-sectional area of condenser shell	21.31 sq.ft.
Cross-sectional area of tubes	4.87 sq.ft.
Net effective area of condenser	16.44 sq.ft.

A mercury manometer was connected to the piping, as shown in plan in Fig. 1 and in photograph, Fig. 2. Fig. 3 was taken after the piping had been removed, but shows where the connections were made. The friction loss through the condenser alone was read on the manometer when valves *A, C* and *E* were open and valves *B* and *D* were closed. The friction loss through the check valve alone was determined by opening valves *E, B* and *D* and closing valves *A* and *C*. The sum of these two losses was checked by opening valves *A* and *D* and closing valves *B, C* and *E*. The manometer then read the total friction loss through the condenser and check valves. The water passes through the shell of the condenser around the tubes, as indicated in Fig. 1, the steam passing through the tubes. Dimensions of the check valve and the condenser are given in Tables 1 and 2 respectively.

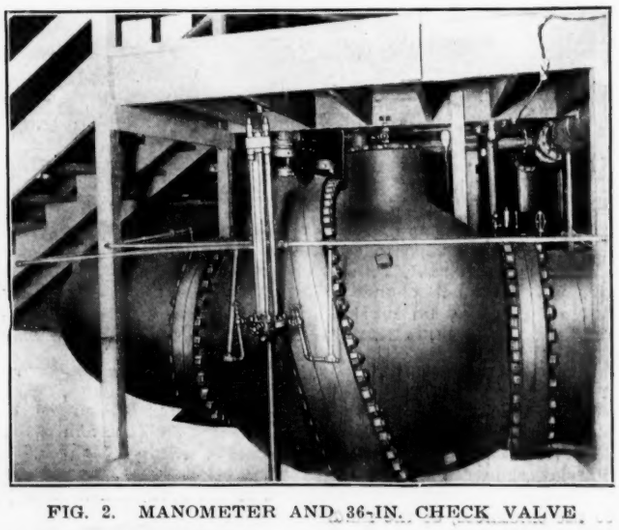


FIG. 2. MANOMETER AND 36-IN. CHECK VALVE

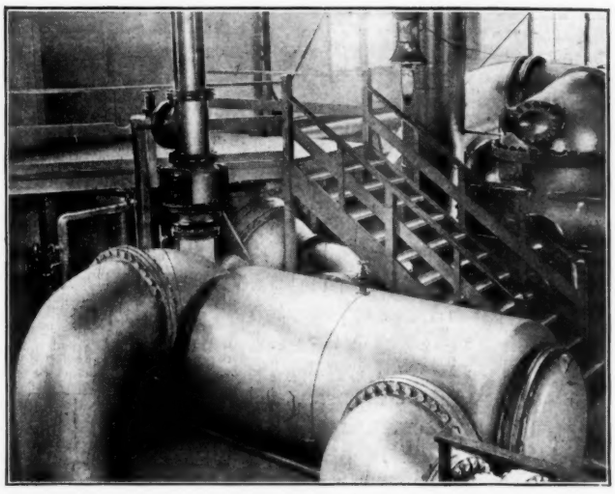


FIG. 3. CONDENSER, SHOWING MANOMETER CONNECTIONS

In order to compare the results obtained with the friction in straight pipe, a curve, Fig. 4, was plotted showing the friction loss in 1,000 ft. of 36-in. pipe, and the similarity between the condenser friction and the pipe friction is apparent. The check-valve friction curve has quite a different characteristic from that of the pipe friction curve, owing to the fact that it required a head of about 0.3 ft. to start the check valves from their seats, but after the valves were once opened the friction loss increased very slowly until a rate of approximately eighteen million gallons was reached.

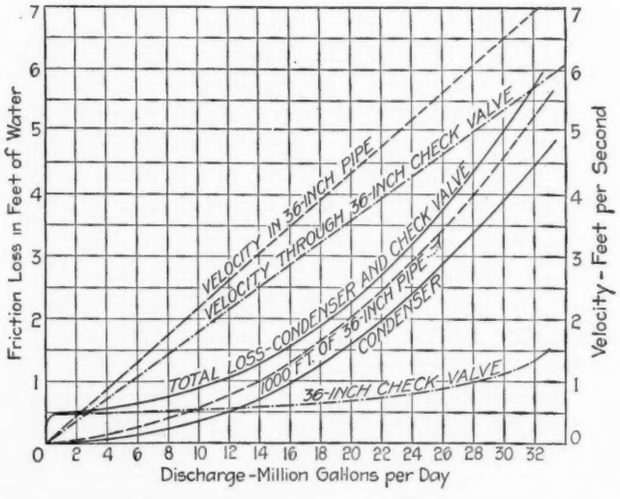

Friction Loss in Feet of Water
Velocity - Feet per Second
Discharge - Million Gallons per Day
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
0 1 2 3 4 5 6 7
VELOCITY IN 36-INCH PIPE
VELOCITY THROUGH 36-INCH CHECK VALVE
TOTAL LOSS-CONDENSER AND CHECK VALVE
1000 FT. OF 36-INCH PIPE
CONDENSER
36-INCH CHECK VALVE

FIG. 4. VELOCITY AND LOSS OF HEAD FOR VARIOUS RATES OF DISCHARGE

Assuming a coefficient of 0.00168, the friction loss through the 36-in. venturi meter when measuring water at a rate of 30,000,000 gal. per day is approximately 1.16 ft. of water. The total friction loss through the condenser, elbow, check valve and venturi meter is therefore 6.16 ft. The additional load on the pump due to this friction is 32.4 water horsepower, which, at a steam consumption of 13.4 lb. per water horsepower-hour, means an additional steam consumption of 434 lb. per hr. at the turbine. Assuming a fuel cost of 12c. per thousand pounds of steam, the additional cost of pumping, due to the friction, would be 5.22c. per hr., or $376 per yr. of 7,200 hr.

The condenser manufacturer expected a loss of not over two feet with thirty million gallons passing through the condenser, and the fact that the actual friction loss was nearer four feet indicates that further experiments on friction loss through condensers would be of value to both the condenser manufacturer and the engineer.

Packing for Ammonia-Compressor Stuffing-Boxes

By F. L. Fairbanks*

SYNOPSIS—Various kinds of ammonia packing are illustrated and described. An asbestos fabric and rubber, self-centering ring is a sensitive and excellent packing. A fibrous sectional wedge ring with cushion gives good service on the rod of a pump discharging 200 gal. per min. of anhydrous ammonia, 24 hr. per day, with no odor of ammonia at the stuffing-box or from the rod.

For the sake of convenient description ammonia-compressor stuffing-box packing may be divided into two principal classes, metallic and fibrous, and these two classes may be again subdivided into two general types, elastic and nonelastic.

Metallic packings of the elastic type are usually composed of segmental rings of two or more segments each, held to the rods by helical or flat springs around their circumferences, two such rings breaking joints being inclosed in each of three or four compartments in a metallic casing usually split and held together by dowels and machine screws through the joint, which is inserted in the stuffing-box. The compartment being larger in internal diameter than the rings allows them to float laterally while following the alignment of the rod and still maintain a comparatively tight joint, both on the rod and on the face of the partition of the compartment.

This is the common type of packing used on steam rods and is desirable principally on large compressors where a considerable amount of clearance, both between the piston and the cylinder and between the crosshead and its guide, is necessary to take care of the expansion and contraction with changes in temperature. This clearance is bound to cause more or less float in the travel of the rod. This type of packing is usually made of cast iron and is shown in Fig. 1.

Another form of metallic packing of the elastic type is that in which the stuffing-box is filled with rings, each composed of two wedge rings, one sliding upon the other. Between each set of metal rings is placed an elastic fibrous ring, usually of rubber or rubber and fabric; an elastic tension is maintained upon the wedge rings by screwing up the gland. The wedge rings of this packing may be made of cast iron or of a combination of the softer alloys that are not subject to the chemical action of ammonia, and are generally composed of two segments to each ring, breaking joints with its companion ring. The angle of the sliding wedge faces is usually about 45 deg., although it may be made almost any angle within a range of from 30 to 90 deg., depending upon the leverage desired to hold the packing up to the rod. Two types, Figs. 2 and 3, are shown, a familiar form being the Katzenstein.

There are several types of the nonelastic metallic packings, which in effect are nothing more than metallic bushings and which, by the application of considerable pressure obtained by screwing up the gland, are compressed sufficiently to fill up the space between the face of the packing and the rod.

One form of this packing, Figs. 4 and 5, consists of a tube composed of the alloys of lead, tin and antimony, each ring being in two sections, breaking joints, the shape of the tube being such that pressure applied by means of the gland collapses the tube in the direction of the length of the rod and decreases its internal diameter sufficiently to take up the wear. Sometimes a rubber gasket ring is used between each tube ring to seal the joints in the tube and to give it slight elasticity.

Another form of nonelastic packing, Fig. 6, is what is known as plastic metal and is composed of a combination of soft alloy and graphite, generally in the form of shot, or gravel, with which the stuffing-box is filled, sometimes in a cloth sack to hold it together, and which is then pressed into the form of a bushing by considerable pressure applied by means of the gland. As the packing wears by contact with the rod, it is forced to a new fit by another application of the gland pressure.

Still another form of this packing, Fig. 7, is the shredded, or ribbon, metallic, composed of a soft alloy shredded into a narrow ribbon or thread, which is twisted into a rope, packed in to fill the stuffing-box and pressed into the form of a bushing by the application of sufficient pressure at the gland in the same manner as with the plastic metal. Sometimes the metallic ribbon is twisted with a strand of fibrous material, such as cotton, flax or asbestos, braided or coiled and pressed into the form of a round or square packing ring in a die, and is inserted in the stuffing-box and held or "taken up" in much the same manner as the ordinary soft packing.

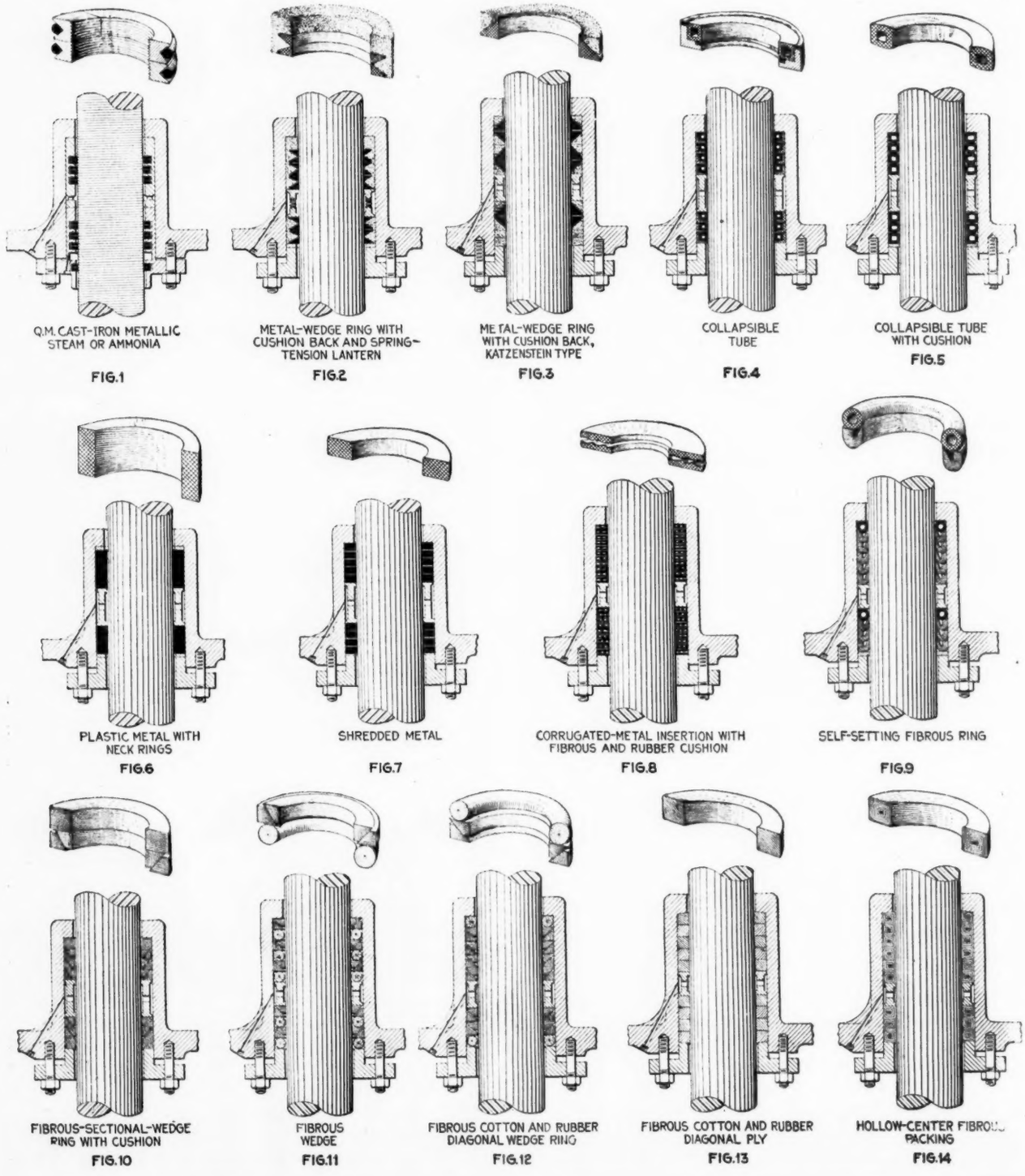
This ring has a slight amount of elasticity for following up wear, and it is sometimes provided with a rubber back or a rubber core to give it the effect of an elastic packing with a metallic wearing face.

*Chief engineer, Quincy Market Cold Storage and Warehouse Co., Boston, Mass.

Rings of a corrugated sheet metal made of a soft alloy and alternated with sheet-rubber rings constitute another form, Fig. 8, in which pressure of the gland tends to straighten out the corrugations, thereby taking up wear, while the rubber rings give a cushion effect.

Practically all of the metallic packings are dry gas packings; that is to say, they require a more or less liberal oil seal to prevent the escape and loss of ammonia gas at the stuffing-box, as well as for lubrication. They will not handle liquid ammonia without considerable loss, for the reason that the liquid ammonia contained in wet gas is mingled with the oil and the packing cannot be set up tight enough under practical operating conditions to prevent the mixture of oil and ammonia coming out with the rod at each outward stroke.

The fibrous packings usually known as soft packings, are generally composed of a combination of rubber and a fabric, or cloth, made of cotton, flax or asbestos, or a mixture of any of the three, mildly vulcanized and cut into rings, or lengths, of different forms, such as round, oval, rectangular, triangular or wedge-shaped, and with rubber cores, rubber backs and laminated rubber and fabric, the laminations being either horizontal, vertical or diagonal, according to the idea of the individual.



VARIOUS FORMS OF PACKING FOR STUFFING-BOXES OF AMMONIA COMPRESSORS

This packing, if not molded in the form of rings, is cut into lengths from the straight piece to form a ring, which will have either a beveled or butted joint and, to have the maximum initial elasticity, should be large enough to be a light driving fit in the stuffing-box.

An efficient but sensitive packing is shown in Fig. 9. This may be made of cotton or asbestos fabric and rubber, properly pressed, vulcanized and cut, with a round soft-metal or stiff fibrous ring for setting out the lip toward the pressure. When properly inserted in the stuffing-box with a good rod, this will give excellent results. It is practically self-setting after it is brought to a fit by gland pressure, which is then relieved to a point just sufficient to keep the packing from having end movement, the lips being held to the rod by the pressure of the ammonia in the recess in each ring.

There are perhaps a hundred different forms and styles of fibrous packings, each giving more or less satisfaction in its particular field and to the user who favors it, and all subject the ammonia rod to more or less wear, depending upon the pressure which is kept applied to the packing by the gland. Some of the more common forms are shown in Figs. 10, 11, 12, 13 and 14.

Rod of Anhydrous Ammonia Pump Odorless

I have found that the wedge-shaped sectional ring of high-grade rubber and cotton fabric, with a flat rectangular ring of the same material at the bottom of the stuffing-box, each side of the lantern and at the gland, all with beveled joints, makes one of the best packings for holding wet gas with a minimum gland pressure and consequent minimum wear of the rod.

With this type of packing, Fig. 10, we are pumping 200 gal. per min., 24 hr. a day, of practically pure anhydrous ammonia, with an 8½-in. pump, against a pressure of 175 to 200 lb. gage and with practically no odor of ammonia at the stuffing-box or on the rod, and this with a repacking twice a year and no appreciable rod wear.

The steam and ammonia rod packings, Fig. 1, used on compressors in the plants of the Quincy Market Cold Storage and Warehouse Co. are identical and interchangeable and are of the cast-iron three-piece segmental-ring type, cut tangentially and held to the rod by a helical spring carried in a V-groove in the circumference of the ring, two rings floating in each compartment of a four-compartment casing provided with a liberal oil seal and drip. The casing is a good fit in the stuffing-box, with a lead-antimony gasket at the bottom of the stuffing-box and between the casing and the gland. The casing has a rod clearance of ⅛ in. and the rings have a horizontal clearance in each compartment, which allows a possible float of $\frac{1}{16}$ in. either way and a vertical clearance between partitions of casing of $^5/_{1000}$ in. Some of the packing has been in service eight years without attention and without any apparent wear of the rod, and from present appearances is good for several years more.

The success of any packing will depend on proper selection, with a knowledge of local conditions, and most important of all, on the individual on whose care and attention it is dependent in service.

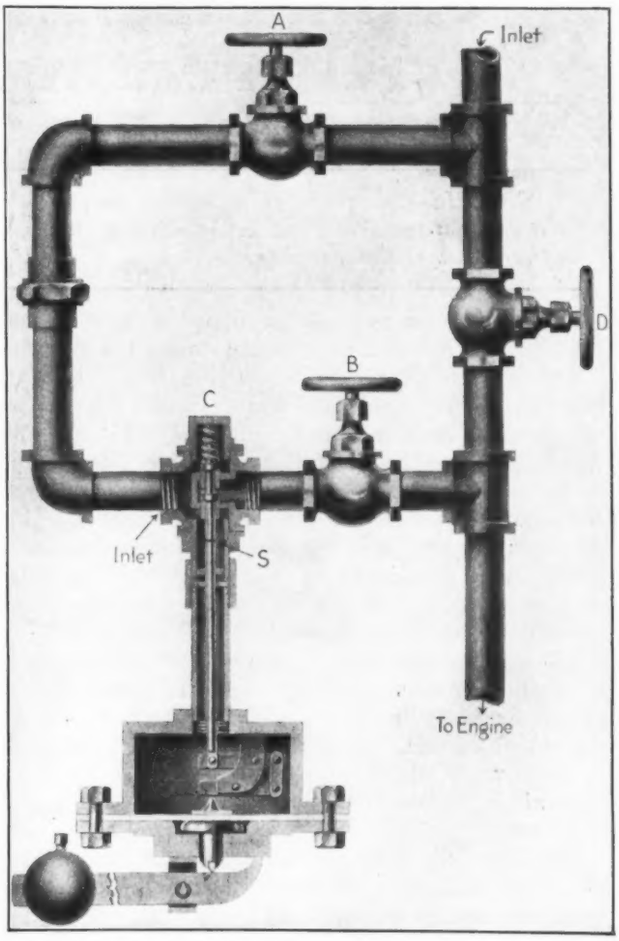
No packing should be expected to rectify the troubles caused by a crooked, scored or badly aligned rod or one which is out of center, out of round, subject to vibration or buckle because too weak to stand the load, or one which is worn smaller in the middle than at the end.

Kitts Fan-Engine Regulator

The Kitts fan-engine regulator is to automatically control the speed of an engine used for driving forced- or induced-draft fans and automatic stoker systems.

The regulator operates with a diaphragm through suitably arranged multiplying levers which give a rapid movement of the valve with a slight movement of the diaphragm. The illustration shows the piping and general construction of the regulator. It is designed for high-pressure service.

The operation is as follows: After the pipe connections are made, the valves *A*, *B* and *D* are closed before



REGULATOR IN SECTION AND PIPE CONNECTIONS

steam is turned into the pipe line; then the valve *A* is opened a little until condensed steam fills the diaphragm chamber to protect the diaphragm from excessive heat, after which the valve is opened wide. The weight on the lever is adjusted until a slight touch on the end will move it up and down.

Before the engine is started, the valve *B* is opened sufficiently to keep the engine running at maximum speed. If the regulator does not slow down the engine with high-steam pressure, the valves *A* and *B* are closed and the cap *C* unscrewed, the valve disks removed and a very little filed off the lower stem of the disks at *S*, so that they will sink deeper in their seats, thereby throttling the steam closer.

The valve is placed at such a distance from the engine that the cubic contents of the pipe between the regulator

and the engine will be at least equal to the cubic contents of the engine cylinder.

When the steam pressure reaches the desired point, say 175 lb., the diaphragm, which has boiler pressure on the upper side, is forced downward and the spring above the upper valve disk will force the double-disks toward the closing position, thus shutting off some of the steam going to the fan engine and slowing it down. As soon as the pressure begins to drop, the reduced pressure under the diaphragm allows the valve to move away from the seats and more steam being admitted to the engine, it speeds up and increases the air supply to the boiler furnace.

The valve is sensitive and is generally controlled within a variation of 2 to 3 lb. When the regulator is used with the stoker and blower engines, the steam regulation is quite close.

This device, manufactured by the Kitts Manufacturing Co., Oswego, N. Y., is not new, but there are many *Power* readers who are not familiar with its operation.

Fundamental Principles of Alternating Current--IV

By F. A. Annett

SYNOPSIS—The procedure of finding the resultant e.m.f. of two sine waves not in phase by means of vector diagrams is explained.

With direct current the resultant of two or more electromotive forces in series is the sum of the individual electromotive forces such as in Fig. 26. Here two battery cells are connected in series, one of 2 volts and one of 1.5 volts, the total e.m.f. being $2 + 1.5 = 3.5$ volts. Again in Fig. 27, which illustrates three direct-current generators in series, of 115, 85 and 240 volts respectively, the resultant e.m.f. is $115 + 85 + 240 = 440$ volts. Fig. 28 shows two sources of electromotive force connected in series, but in opposition; the resultant being their difference, or 110 volts. If the two voltages were equal, the potential between the outside legs would be zero.

Likewise, for the current, where the circuit is made up of several branches in parallel the total current flowing in the system is the sum of the currents flowing in the individual circuits. For example, in Fig. 29, the circuit is made up of three branches of 25, 42 and 16 amp. respectively, and the total current in the external circuit is 83 amp.

When two sine-wave alternating-current generators of the same frequency are connected in series, the resultant voltage across the two outside terminals will depend upon the phase relation between the two machines and will not necessarily be the sum or the difference of the two e.m.f.'s. Consider two alternators A and B, of 115 and 75 volts respectively, connected in series, and let it be assumed that the e.m.f.'s of the two machines pass through their corresponding parts of the cycle at the same instant, as indicated by Fig. 30. This condition is usually referred to as the voltages or currents being in step or in phase. In this particular case the voltage across the two machines will be the sum of the two individual e.m.f.'s, or 190 volts. The dotted curve represents the sum of the instantaneous voltage values and is obtained by adding the instantaneous values on the curve of each individual machine; that is, $cd = ac + bc$ and od', the maximum of the dotted curve, equals oa', the maximum of curve A, plus ob', the maximum of curve B.

If the voltages of the two machines are in direct opposition, as indicated in Fig. 31, the resultant effective e.m.f. will be the difference, or $115 - 75 = 40$ volts. The dotted curve is the resultant e.m.f. wave obtained by taking the difference of the instantaneous values on the curve of each individual machine; thus $od' = oa' - ob'$. When two alternators are connected with the voltage of one directly opposing that of the other, as in Fig. 31, they are said to differ in phase by 180 deg.

In practice, however, the electromotive forces of the individual machines are not always in step, or in direct opposition; hence the resultant voltage or current will not necessarily be the arithmetical sum or difference. For example, consider two alternators in series with their e.m.f.'s in the relation indicated in Fig. 32. In this case the e.m.f.'s do not pass through their corresponding periods at the same instant, that of machine A reversing before that of machine B. From positions e to f they are in the same direction; therefore the instantaneous values between these two points will be the sum of the instantaneous e.m.f.'s of the individual curves. At f the e.m.f. of machine A reverses and is in opposition to that of machine B until point g is reached, where the e.m.f. of machine B becomes zero; consequently from f to g the resultant instantaneous values will be the difference between those of the individual machines. From g to h the e.m.f.'s are in the same direction, therefore are added together. During the last period of the cycle from h to i they are again in opposition, and the resultant will be their difference.

It was shown in Part I (Dec. 7 issue) that if the radius of the circle through which a conductor is revolving in a uniform magnetic field is taken to represent the maximum electromotive force (E) the vertical distance between the conductor and the neutral axis represents the instantaneous electromotive force (e) in any position. This is again indicated in Fig. 33, or in simpler form by Fig. 34, which is called a "vector diagram." Here ϕ represents the angle through which the conductor or group of conductors has revolved with reference to the neutral axis. It was also shown in Part I that the sine of an angle of a right triangle equals the opposite side divided by the hypotenuse. Then in Fig. 34 sine $\phi = \frac{e}{E}$; hence $e = E$ sine ϕ, which means that the value of a sine wave of electromotive force or current at any instant equals the maximum value of the curve times the sine of the angle through which the conductor has passed.

To illustrate this, in Fig. 35 it is assumed that the maximum e.m.f. is 315 volts.

(1) Find the instantaneous value of e at 50 deg.

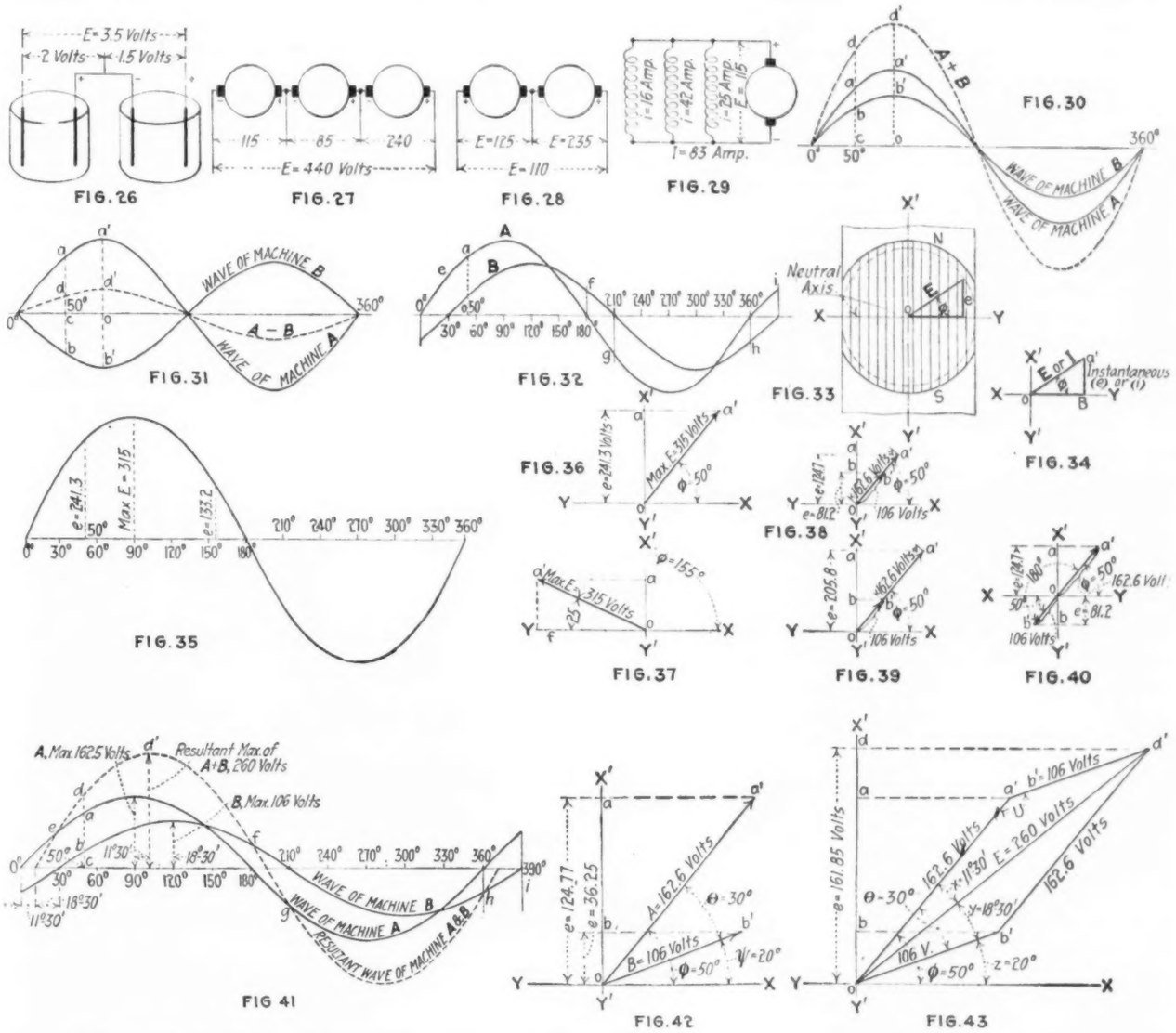
The sine of 50 deg. is 0.766 (see Table 1, Part I). Hence $e = 315 \times 0.766 = 241.3$ volts. This is shown on the curve, Fig. 35, and the vector diagram, Fig. 36.

(2) Find the instantaneous value of e at 155 deg. (Fig. 35).

The sine of 155 deg. is the same as the sine of (180 deg. — 155 deg.) = sine 25 deg. = 0.423. Therefore, $e = 315 \times 0.423 = 133.2$ volts, as indicated in Fig. 35.

they will coincide, and the vertical distances oa and ob will represent the e.m.f.'s of machines A and B respectively, at this instant. If oa' and ob' in the vector diagram are made to equal oa' and ob' on the curve (Fig. 30), then oa and ob in the vector diagram will equal ac and bc respectively on the curves (Fig. 30).

Such a diagram is known as a "polar vector diagram." It is defective in that it does not show the resultant of the maximum or instantaneous values. Fig. 39 is a diagram which overcomes this defect and is known as a "topographic vector diagram." Here the two maximums are



FIGS. 26 TO 43. ILLUSTRATING THE COMBINING OF VOLTAGES AND CURRENTS BY VECTOR DIAGRAMS

The same method applies to a sine wave of alternating current; that is, $i = I$ sine ϕ where i is the instantaneous current and I the maximum current.

By projecting a' horizontally the instantaneous value may be shown on the vertical axis $X'Y'$, as indicated by oa in Figs. 36 and 37. Henceforth the instantaneous value will be represented on the vertical axis.

Fig. 38 is a vector diagram showing the relation between the two e.m.f.'s at the 50-deg. point previously represented by Fig. 30. The line oa' (Fig. 38) represents the maximum pressure of machine A, and ob' the maximum of machine B. Since the voltages are in step, combined in their proper phase relation; and where the two e.m.f.'s are in step they will fall in the same straight line and in the same direction, the resultant being the arithmetical sum of the two. Applying this diagram to the conditions considered in Fig. 30, we have oa' (Fig. 39) corresponding to od' (Fig. 30); likewise for the instantaneous values ob and ba (Fig. 39) will equal bc and ac (Fig. 30) respectively. The values of oa and ob may be found as follows:

$$\text{Maximum e.m.f.} = \frac{\text{effective e.m.f.}}{0.707}$$ (See Part II, Dec. 21 issue). Therefore, the maximum e.m.f. of

machines A and B (Fig. 30) will equal $\frac{115}{0.707} = 162.6$ volts and $\frac{75}{0.707} = 106$ volts, respectively.

In Fig. 38 $oa = oa' \times$ sine 50 deg. As $oa' = 162.6$, and sine 50 deg. $= 0.766$, then $oa = 162.6 \times 0.766 = 124.7$ volts. Also, $ob = ob' \times$ sine 50 deg. $= 106 \times 0.766 = 81.2$ volts. In Fig. 39 $b'a'$ equals oa' (Fig. 38), hence oa' (Fig. 39) equals $ob' + b'a' = 106 + 162.6 = 268.6$ volts; and $oa = oa' \times$ sine 50 deg. $= 268.6 \times 0.766 = 205.8$ volts. This checks up with the sum of oa and ob (Fig. 38), which is $124.7 + 81.1 = 205.8$ volts.

Fig. 40 is a polar vector diagram of the e.m.f.'s of the generators referred to in connection with Fig. 31. Since the voltages are in direct opposition ob', which represents the maximum e.m.f. of B, will be drawn 180 deg. from oa', which represents the maximum e.m.f. of A. In this diagram, as in Fig. 38, there is no line representing the resultant maximum or instantaneous value. Of course they may be found by subtracting ob' from oa' for the resultant maximum, or $162.6 - 106 = 56.6$ volts, and ob from oa for the resultant instantaneous value; that is, $124.7 - 81.1 = 43.6$ volts.

The relation represented in Fig. 32, and again in Fig. 41, may be shown in the same way. Suppose it is desired to find the resultants at the instant when A has passed through 50 deg., as indicated on the curve; since B is 30 deg. behind A, 50 deg. on A will be 20 deg. on B. This condition is indicated in the vector diagram, Fig. 42, where oa' is drawn to scale to represent the maximum of A, making an angle of 50 deg. with the horizontal axis XY, and ob' is drawn to scale to represent the maximum of B, 30 deg. behind oa'. The distances oa and ob on the vertical axis will represent the instantaneous values of A and B respectively, and oa' may be combined with ob' to show the resultant maximum and instantaneous values, as in Fig. 43. Here oa' and ob' have been drawn as in Fig. 42, and then $a'd'$ is drawn parallel to ob', and $b'd'$ parallel to oa', forming the parallelogram $oa'd'b'$ with $a'd' = ob'$ and $b'd' = oa'$. The distances oa and ad will equal the voltages of A and B respectively at this instant, and od their resultant, which is equivalent to cd (Fig. 41). The diagonal od' will equal the resultant maximum voltage of A and B corresponding to od' on the dotted curve, Fig. 41.

The maximum e.m.f.'s of machines A and B are the same as in Figs. 30 and 38. The resultant maximum, od', may be calculated from the formula

$$(od')^2 = (oa')^2 + (a'd')^2 - 2oa' \times a'd' \times \cos U$$

Angle $U = 180$ deg. $-$ angle $\theta = 180$ deg. $- 30 = 150$ deg., and cos 150 deg. $=$ $-$ cos 30 deg., or $- 0.866$.

Substituting the numerical values,

$$(od')^2 = (162.6)^2 + (106)^2 - [2 \times 162.6 \times 106 \times (-0.866)] = 67526.82$$

whence $od' = 260$ volts (approximately).

Again,

$$(a'd')^2 = (od')^2 + (oa')^2 - (2 \times od' \times oa' \cos x)$$

and

$$\cos x = \frac{(od')^2 + (oa')^2 - (a'd')^2}{2 \times od' \times oa'}$$

$$= \frac{(260)^2 + (162.6)^2 - (106)^2}{2 \times 260 \times 162.6} = 0.980$$

Referring to Table 1 (Part I) it will be found that the cosine of 11 deg. $= 0.982$ and that of 12 deg. $= 0.978$. As 0.980 lies between these values, the angle x will be 11 deg. 30 min., and angle $y = 30$ deg. $-$ 11 deg. 30 min. $= 18$ deg. 30 min.

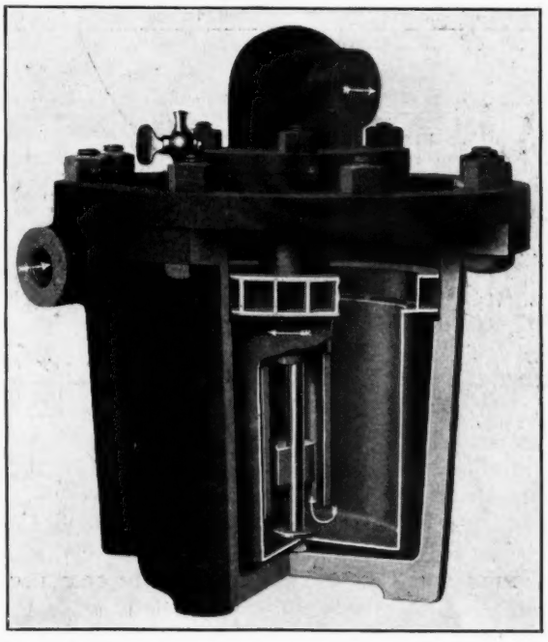
From the foregoing it is seen that the resultant of oa' and ob' falls 11 deg. 30 min. behind oa' and 18 deg. 30 min. ahead of ob'. This is the position of the dotted curve relative to the curves A and B, as shown in Fig. 41.

The resultant instantaneous value of od is found by the formula $od = od' \times \sin(y + z)$; that is, $e = E \sin(y + z)$ Substituting the numerical values $e = 260 \times 0.6225 = 161.85$ volts (approximately).

The method used in finding the resultant maximum and instantaneous values may be applied in finding the resultant effective value. Also, inasmuch as the effective value of a sine curve equals the maximum times 0.707, the effective voltage across the two machines may be obtained by multiplying the resultant maximum, as found in Figs. 41 and 43, by 0.707. The resultant maximum in Figs. 41 and 43 is 260 volts. The voltmeter reading $E \times 0.707 = 260 \times 0.707 = 183.8$ volts. The combining of two sine curves produces a third curve, which is itself a sine curve.

Revolving-Bucket Steam Trap

The main feature of construction in the "R-P" steam trap is that of the revolving bucket, the motion of which automatically clears and burnishes the valve seat each time the valve closes. This keeps the seat tight, and wiredrawing and leakage past the valve are prevented.



TRAP HAVING A REVOLVING BUCKET

Steam entering tangentially the pockets which are provided at the top of the bucket, as shown in the illustration, causes the bucket, stem and valve to rotate.

The water of condensation enters at the bottom of the trap. It also enters on a tangent and keeps in an agitated condition what mud and sediment there may be so that they are blown out through the discharge line.

This trap is manufactured by the John F. Robertson Co., 1001 Park Building, Pittsburgh, Penn.

Acceptance Tests of B. & W. and Stirling Boilers

By L. A. Quayle*

SYNOPSIS—Figures of tests showing performances exceeding those guaranteed by 2 to 5.1 per cent.

Owing to obsolescence and the large demand for steam to supply the mains of the municipal heating system at Cleveland, Ohio, which was started in the fall of 1912, the small Fairmount Station boiler house built in 1885 has been enlarged, a 200x10 ft. diameter chimney built and new equipment installed. The main equipment consists of two 500-hp. Babcock & Wilcox boilers that were put in operation in January, 1913, two 500-hp. Stirling boilers that were put in operation in the spring of 1914 and one 500-hp. Stirling boiler that has been in service for about six months. All boilers are equipped with Babcock & Wilcox chain-grate stokers. General views of the boiler room are shown in Figs. 1 and 2.

When using a free-burning slack containing not less than 13,500 B.t.u. per lb., the ash not to exceed 13 per cent., the sulphur to be less than 3½ per cent. and the draft to be not less than that given in the table, the Babcock & Wilcox Co. guaranteed that the boiler and stokers would attain the following efficiencies:

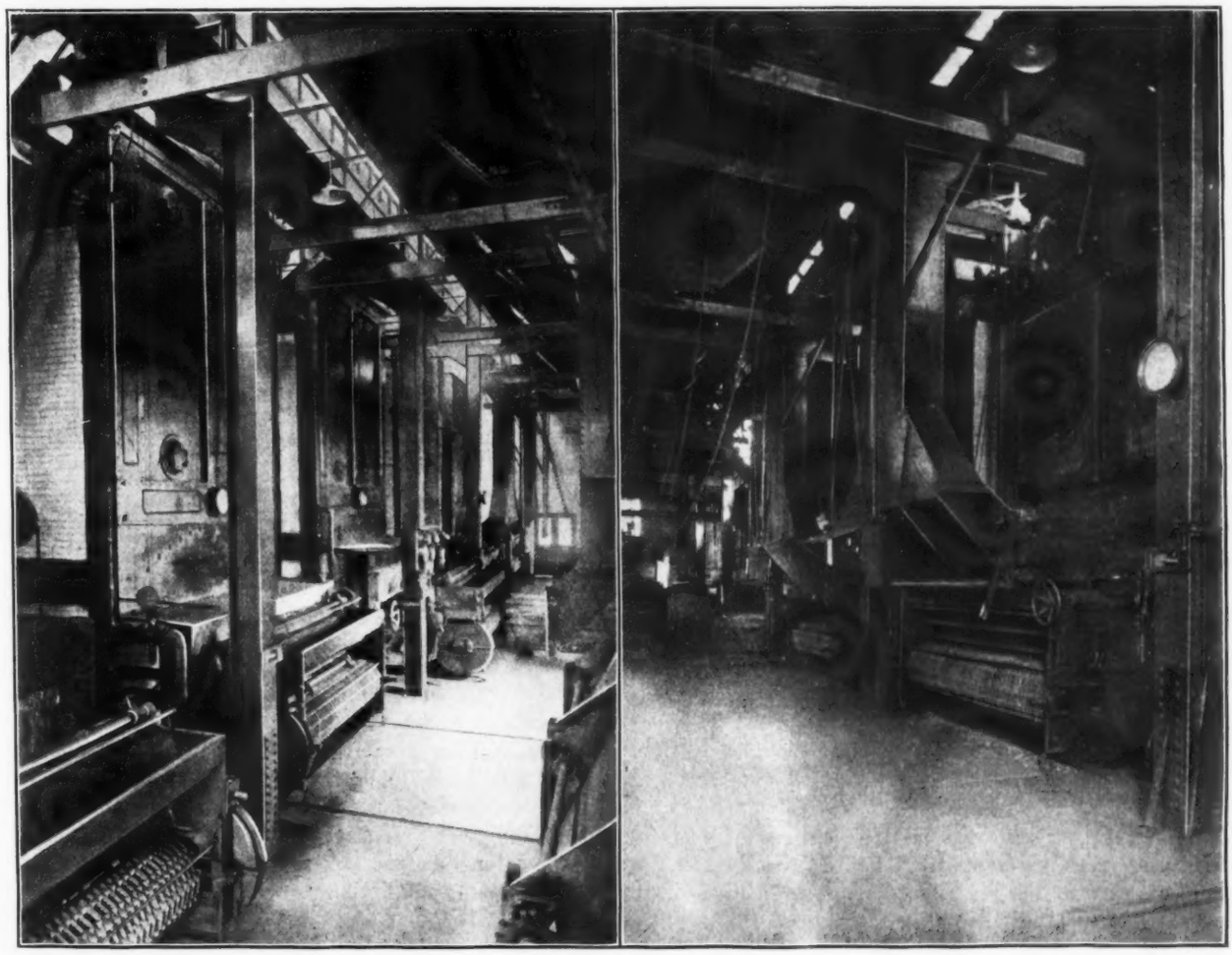
Combined Guarantees of Boiler and Stoker	Two 500-Hp. B. & W. and one 500-Hp. Stirling			Two 500-Hp. Stirling		
Load in percentage of rating	100	150	200	100	150	200
Draft at damper (inches)	0.55	0.7	1.1	0.55	0.7	1.1
Efficiency of boiler and stoker, %	70	70	68	68	68	66
Moisture in steam not to exceed, %	1.0	1.25	1.5	1.0	1.5	2.0

The three Stirling boilers are identical in construction; but a higher guarantee was made on the one purchased last, this guarantee being the same as was made on the two Babcock & Wilcox boilers.

In accordance with the policy of the Cleveland Water Department as established by C. F. Schulz, commissioner of water, to thoroughly test all equipment before final acceptance, one boiler of each type was tested at slightly less than 150 per cent. of rating.

Owing to the fact that one of the competitors of the successful bidder threatened to enjoin the city from the purchase of the Stirling boilers because the Stirling bid was not the lowest in price but was lowest when the guarantees were capitalized, it was considered advisable

*Asst. Engr. Division of Power, Dept. of Public Utilities, City of Cleveland.



FIGS. 1 AND 2. VIEWS IN BOILER ROOM OF CLEVELAND PUMPING STATION WHERE TESTS WERE MADE

to run the test in conjunction with a disinterested party and George S. Rider & Co., consulting engineers, were selected.

Before the test was started, the blowoffs were blanked off with blind flanges and all connections from the feed pump to the boiler, through which water might leak out if the valves were not tight, were blanked, so that no valves were depended upon the leakage of which could affect the determination of the weight of the water evaporated by the boiler.

The water was weighed in the tank, shown in Fig. 4, by use of the calibrated scale. The water was discharged

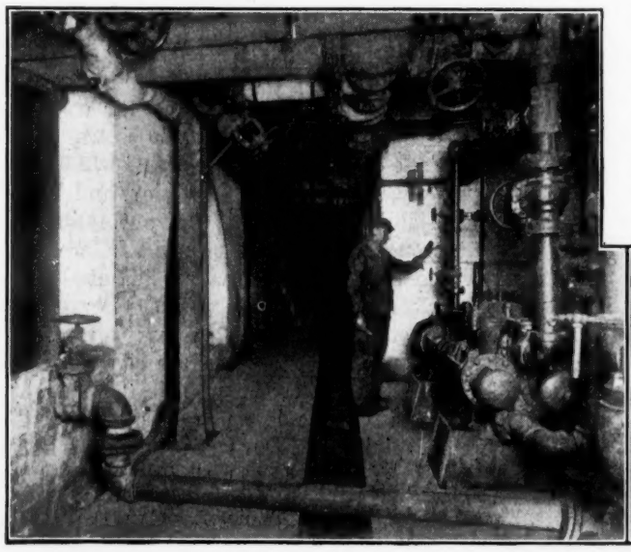


FIG. 3. FEED-WATER TANK AND PUMP

from this tank into a tank in the basement, shown at the left in Fig. 3, from which the boiler-feed pump, also shown, took its suction. A small amount of water dripped from the pump plungers and was caught in pails and weighed.

The coal was weighed in the hopper scales shown in Figs. 1 and 2. These scales were calibrated by the city sealer and also by weighing a given amount of coal in them and then dumping it on the floor and reweighing it on a scale that had been tested with 50-pound test weights. The dryness of the steam was tested by a throttling calorimeter, which had been calibrated before the test in the following manner: The boiler to be tested was shut off from the steam header and a light fire put under it. All the steam generated by the boiler was blown through the orifice of the calorimeter. Simultaneous readings of the temperature in the calorimeter and pressure in the boiler were taken as the pressure in the boiler gradually rose from 125 to 155 lb., readings being taken for each two pounds rise in pressure.

The following formula was used in determining the dryness of the steam:

$$\textit{Per cent. moisture} = \frac{0.48\,(T - t)}{L} \times 100$$

The flue temperature was taken by the use of a Leeds & Northup electric pyrometer. The draft readings at the damper and over the fire were taken with Ellison draft gages. The speed of the stoker engine and the position of the damper were regulated by hand. The flue-gas analysis was taken by the use of an Orsat gas analyzer. Smoke readings were taken by the use of a Ringelmann chart.

Readings of pressures, temperatures, etc., were taken every 15 min. At the end of each hour the coal hoppers were leveled off, the weight of the water evaporated determined and the approximate efficiency computed to show whether or not the results were running uniformly.

Great care was exercised in seeing that the condition of the fire, the height of the water in the boiler and the steam pressure were the same at the beginning and end of the test. The dimensions of the boilers and the results of the tests are given in the table on the following page.

The Stirling boilers have the standard three-pass baffling, and the Babcock & Wilcox boilers have the vertical three-pass baffling.

Preliminary tests on the Babcock & Wilcox boilers showed more smoke than as guaranteed. A section of the lower row of tubes which came in direct contact with the flame was covered with tube brick, and the use of this

FIG. 4. TANK SCALE FOR WEIGHING FEED WATER

brick reduced the smoke inside of the guaranteed limit.

The heat value of the coal used on each test was determined by the Water Department chemist, the Babcock & Wilcox Co.'s chemist and by a local chemical laboratory. The average of these three analyses was used in computing the test results.

The difference in the cost of coal per ton on the two tests is due to the difference in heat value. The coal used by the Water Department is purchased on the bonus-and-penalty heat-value basis, the standard price being $1.64 per ton for coal containing 13,000 B.t.u. per lb.

The coal fed to the stokers was wet by water discharged through a perforated pipe above the boiler coal hopper to make it burn more freely. The efficiency on the test of the Stirling boiler would have been somewhat higher had it not been for the fact that the coal bunker from which the boiler was fed contained a quantity of exceedingly fine slack which made it necessary to change the thickness of the fire and increase the draft to burn it. This fine coal lasted about two hours, and the efficiency obtained during these two hours was considerably lower than the average for the test.

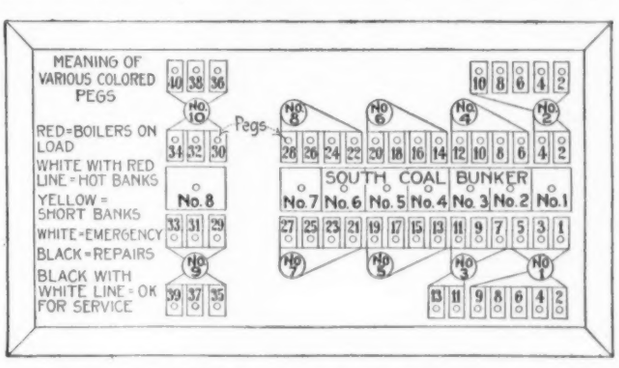
As can be seen from the results cited, the efficiency of the boiler and stoker exceeded the guarantees by 2 per cent. on the Babcock & Wilcox boilers, 5.1 per cent. on two of the Stirling boilers and 3.1 per cent. on the Stirling boiler that was purchased last. The results in detail are as follows:

ACCEPTANCE TESTS OF B. & W. AND STIRLING BOILERS

Dimensions, Proportions, Etc.	Test of Babcock & Wilcox Boiler No. 2	Test of Stirling Boiler No. 3
Kind of boiler	Standard B. & W. water-tube	Stirling Class O No. 20.
Kind of furnace	Standard B. & W. chain-grate	Standard B. & W. chain-grate with B. & W. flat arch.
Grate surface	Width 10 ft., length 10 ft., area 100 sq.ft.	Width 9 ft., length 11 ft., 6 in., area 103.5 sq.ft.
Proportion of air space to grate surface	17.9 per cent.	17.9 per cent.
Number of steam drums	2	3.
Diameter of steam drums	42 in.	42 in.
Length of steam drums	23 ft., 3½ in.	13 ft., 10½ in.
Number of mud drums	1	1.
Cross-section of mud drum	7.25 in. square	
Diameter of mud drum		48 in.
Length of mud drum	11 ft. 7 in.	11 ft., 7⅛ in.
Number of 2½-in. feed pipes	2	1.
Number of 2½-in. blowoffs	3	1.
Number of water tubes	252	360.
Number of sections of tubes	18	
Diameter of tubes	4 in.	3¼ in.
Number of tubes per section	14	
Length of tubes	18 ft.	18 ft., 2¾ in.
Total water-heating surface	5,120 sq.ft.	5,019 sq.ft.
Ratio of water-heating to grate surface	51.2 to 1	48.5 to 1.
Date of test	Sept. 1, 1915	Sept. 21, 1915.
Duration	12 hours	12 hours.
Kind of coal	Bituminous-Pittsburgh	Bituminous-Pittsburgh.
Size of coal	Slack	Slack.
Coal furnished by	Valley-Camp Coal Co.	Valley-Camp Coal Co.
Average Pressures, Temperatures, Etc.		
Steam pressure by gage	145.5 lb.	144.4 lb.
Barometric pressure	14.4 lb. (29.39 in.)	14.3 lb. (29.05 in.)
Steam pressure, absolute	159.9 lb.	158.7 lb.
Force of draft at damper	0.59 in.	0.61 in.
Force of draft in furnace	0.29 in.	0. 30 in.
State of weather	Clear, dry	Cloudy.
Temperature of fireroom	71.6 deg. F.	59.6 deg. F.
Temperature of water entering boilers	72.0 deg. F.	74.2 deg. F.
Temperature of gases leaving boilers	513 deg. F.	556 deg. F.
Quality of Steam		
Moisture in steam	0.0 per cent.	0.0 per cent.
Quality of steam (dry steam—unity)	100 per cent.	100 per cent.
Total Quantities		
Weight of coal as fired	31,961 lb.	32,064 lb.
Moisture in coal	3.25 per cent.	5.02 per cent.
Total weight dry coal consumed	30,922 lb.	30,454 lb.
Total ash and refuse weighed	3,993 lb.	3,562 lb.
Total cinders drawn through boiler	312 lb.	258 lb.
Total clinker		237 lb.
Total ash and refuse corrected for cinders	4,305 lb.	4,057 lb.
Total combustible consumed	26,617 lb.	26,397 lb.
Ash and refuse in dry coal	13.9 per cent.	13.3 per cent.
Total weight of water fed to boiler and evaporated	263,208 lb.	256,725 lb.
Factor of evaporation	1.189	1.187.
Total equivalent evaporation from and at 212 deg.	313,139 lb.	304,784 lb.
Hourly Quantities and Rates		
Dry coal consumed per hr.	2,577 lb.	2,538 lb.
Combustible consumed per hr.	2,218 lb.	2,200 lb.
Dry coal per sq.ft. of grate surface per hr.	25.8 lb.	24.5 lb.
Water evaporated per hr.	21,934 lb.	21,394 lb.
Equivalent evaporation per hr. from and at 212 deg. F.	26,096 lb.	25,399 lb.
Equivalent evaporation per hr. from and at 212 deg. per sq.ft. water-heating surface	5.09 lb.	5.06 lb.
Proximate Analysis of Coal		
Fixed carbon	53.18 per cent.	51.84 per cent.
Volatile matter	33.36 per cent.	32.17 per cent.
Moisture	3.25 per cent.	5.02 per cent.
Ash	10.21 per cent.	10.97 per cent.
	100.00 per cent.	100.00 per cent.
Sulphur separately determined	3.08 per cent.	2.65 per cent.
Analysis of Ash and Refuse		
Moisture in ash	0.00 per cent.	1.35 per cent.
Volatile	1.42 per cent.	2.47 per cent.
Carbon	24.67 per cent.	12.71 per cent
Ash	73.91 per cent.	84.87 per cent.
	100.00 per cent.	100.00 per cent.
Calorific Value		
Calorific value of 1 lb. of dry coal by calorimeter	13,638 B.t.u.	13,288 B.t.u.
Calorific value of 1 lb. of combustible by calorimeter	15,247 B.t.u.	15,023 B.t.u.
Capacity		
Evaporation per hr. from and at 212 deg.	26,095 lb.	25,399 lb.
Boiler horsepower developed	756.3	736.
Rated capacity, from and at 212 deg.	17,664 lb. per hr.	17,319 lb. per hr.
Rated boiler horsepower	512	502.
Percentage of rated capacity developed	147.7 per cent.	146.6 per cent.
Economic Results		
Water fed per lb. of coal	8.23 lb.	8.01 lb.
Water evaporated per lb. of dry coal	8.51 lb.	8.43 lb.
Equivalent evaporation from and at 212 deg. per lb. of coal fired	9.79 lb.	9.50 lb.
Equivalent evaporation from and at 212 deg. per lb. of dry coal	10.13 lb.	10.01 lb.
Equivalent evaporation from and at 212 deg. per lb. of combustible	11.76 lb.	11.55 lb.
Dry coal per hp.-hr. developed	3.5 lb.	3.4 lb.
Efficiency of boiler, furnace and grate	72.0 per cent.	73.1 per cent.
Efficiency of boiler and furnace	74.8 per cent.	74.6 per cent.
Guaranteed efficiency of boiler, furnace and grate	70.0 per cent.	68 & 70.0 per cent.
Cost of Evaporation		
Cost of coal per ton of 2,000 lb. delivered	$1.73	$1.685.
Cost of coal required for evaporating 1,000 lb. of water under observed conditions	10.51 cents.	10.52 cents.
Cost of coal required for evaporating 1,000 lb. of water from and at 212 deg.	8.83 cents.	8.86 cents.
Smoke Data		
Percentage of smoke observed	20 per cent. black.	15 per cent. black.
Firing Conditions		
Average thickness of fire	6.25 in.	6.0 in.
Condition of coal as fired	Wet after weighing.	Wet.
Analysis of Dry Gas by Volume		
Carbon dioxide (CO_2)	10.48 per cent.	13.51 per cent.
Oxygen (O_2)	8.97 per cent.	5.53 per cent.
Carbon monoxide (CO)	0.17 per cent.	0.07 per cent.
Nitrogen (N) (by diff.)	80.38 per cent.	80.89 per cent.
	100.00 per cent.	100.00 per cent.

A Handy Boiler Peg Board

The accompanying diagram, showing the arrangement of the boilers, stacks and coal bunkers in the Ashley Street station of the Union Electric Light and Power Co., of St. Louis, is on a board conspicuously located in the boiler house and, by the use of wooden pegs, is a means of continuously showing the conditions under which the boiler plant is operating. Each of the stacks is shown with the



BOARD FOR INDICATING WHAT BOILERS ARE ON

relative position of all boilers connected to it. The lower-deck boilers are those nearest the upper and lower edges of the diagram and the upper-deck boilers are nearer the center of the diagram. Each of the boilers is represented by a small rectangle in the center of which a hole is drilled. Various-colored pegs are inserted in these holes, each color representing some special operating condition. For instance, a red peg indicates that the boiler is under fire and carrying load. A white peg with red lines across the center shows the boiler to be in what is called a "hot-bank" condition. This is a boiler under which there is a fire anywhere from 4 ft. long to the full length of the grate, fully ignited and making enough steam to keep the boiler on the header. The boiler in this condition can be brought up to full load in about 6 to 8 minutes.

A yellow peg indicates the boiler to be on "short bank." Here the fire is about 18 in. long and is sufficient to maintain the settings hot and a steam pressure of 60 to 120 lb. A white peg indicates that the boiler is set ready

for quick ignition and emergency operation in case of trouble with the water-power carrying part of the load. The emergency boilers are filled with water. High-grade coal is run onto the grates, and upon this coal in trenches extending across the grate are placed oily rags and kindling. Extending down the center of the grate there is also a longitudinal trench filled with oily rags, which serves to spread the ignition from the front part of the furnace to the rear. In this way it is possible to get a white-hot fire inside of 10 min., and the boilers have been brought up from a cold condition to header pressure and delivering full load within 40 min.

A black peg indicates that the boiler is being repaired, and a black peg with white lines across the center is inserted when the boiler is ready for service.

The rectangles shown in the middle of the diagram and numbered consecutively represent the coal bulkheads above the boilers. These are emptied in rotation to avoid the burning of coal from spontaneous combustion. A peg inserted in holes within these rectangles indicates which of the bulkheads is being emptied.

This board is a great convenience both to the engineers and firemen, in that it shows the relation of each unit to the whole scheme of operation, and in so doing facilitates the thinking out and use of those combinations that lead to best economy of operation.

*

Compressor Valve Stuck Open

By Thomas G. Thurston

The machine in question consisted of two vertical, single-acting compressors driven by a simple noncondensing Corliss engine. One day the machine began to race badly, but the engineer could find nothing wrong with the governor and valve gear, and he finally had to throttle the machine, but this did not completely stop the racing. About this time he noticed that the crankpin of one of the compressors was smoking. He stopped the machine, let the pin cool and forgot about the first trouble. When he started again the machine ran all right, but a few days later the same thing happend, and this time he also failed to notice anything wrong until he saw the smoking pin.

It was not very many days before the same thing happened again, and this time he throttled the engine at once and directed his attention to the crankpin, which became hot. This happened several times, until, looking at the ammonia gages one day, he noticed that they were vibrating much more than usual. Paying closer attention, he noticed that they worked in the reverse direction at the same moment; that is, the head pressure would increase and the back pressure decrease at the same time, and then the reverse would occur. There was only one vibration for each revolution of the machine.

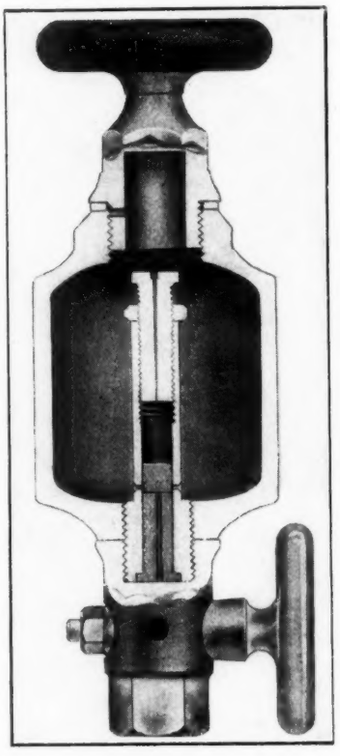
After thinking this over, he concluded that only one compressor could be working, because if both had been working there should have been one vibration for the discharge of each compressor, or two for each revolution. Going on top of the machine, he found the frost thawing rapidly on the suction line to the compressor that had been giving trouble. Also there was a whistling sound in the discharge valve of the compressor and the cylinder and piston rod were much hotter than those of the other machine.

On removing the valve, the cause of the trouble was evident—the valve was stuck open. Thus full head pressure was maintained on the piston during the whole revolution, and this put extra pressure on the crankpin, causing it to heat. This also explained the racing of the machine, as it was working only on one side at times, as the valve obviously stuck intermittently. The valve also evidently stuck when it got hot, and this would explain why the machine would run all right after it had been shut down for a while. The valve was dry and badly gummed, but when cleaned and oiled the compressor gave no further trouble.

*

Federal Graphite Lubricator

The graphite lubricator illustrated herewith is designed to feed dry graphite to the cylinders of engines, pumps, compressors, etc. The chamber has a capacity of 6 oz. of flake graphite and contains a standard in which there are small port-holes through which the graphite passes. The size and nature of these ports are suited to the grade of graphite to be used, and they are made standard in three sizes for feeding the largest and medium flake graphite. The lubricator is fitted with a three-way valve to drain the connecting line should there be condensation in it or in the cylinder. The bottom connection is a ½-in. standard thread that fits the indicator pipe connection. The top of the lubricator is removable for filling the chamber. The joint is made tight by a lead washer. The operation of the device is as follows: A cylindrical plunger valve, the only moving part, rises and falls with each pulsation in the lubricator, causing a rush of steam or air through the port-holes, which carries the flakes of graphite to the cylinder to be lubricated. When the pressure equalizes inside and outside of the chamber, the valve closes by gravity and cuts off the feed until the plunger is raised again by the next increase in pressure in the lubricator cylinder.



DRY-GRAPHITE LUBRICATOR

When the flakes of graphite enter the cylinder in suspension with the steam, air or gas, they become attached to the friction surfaces and, being caught between the working surfaces, are distributed over whatever surfaces they touch.

This lubricator, which is manufactured by the Federal Graphite Mills, Cleveland, Ohio, is usually fitted to the steam-indicator connection of the cylinder by means of the two-way cock. Any other connection can be made convenient for any particular engine or pump.

Editorials

Renewing Economizer Tubes

During the discussion of his paper upon the "Standardization of Power-Plant Operating Costs," presented to the New York section of the American Society of Mechanical Engineers, Walter N. Polakov said that in attempting to standardize the time required for the renewal of economizer tubes, they had found that one of the engineers at the Cos Cob Station had a trick whereby he could renew a tube in about one-third of the time the process ordinarily requires. Knowing that *Power* readers would appreciate just this kind of a kink, we inquired after the meeting who the engineer was, with the idea of soliciting a contribution upon the subject, but were met with the assertion by Mr. Polakov that it would be of no use, that he had offered the man a thousand dollars for his secret only to be refused and that the man would not use his process when anyone was watching him.

The removal of an economizer tube and the insertion of another is not such an abstruse process as to afford opportunity for much legerdemain, and if there is a short and easy way of doing it which is so well worth while, there are plenty of geniuses among the readers of *Power* who can find it or one as good. How long does it take on an average at your plant to renew an economizer tube? How do you go about it? How do you suppose the Cos Cob man does it? For the interested mechanic who never had to do this particular job, the description of what is required and the usual way of doing it is given on page 174.

The question is now open for discussion.

Industrial Preparedness

In a speech before the New York Trade Press Association, Thursday evening, January 20, W. L. Saunders, chairman of the Board, Ingersoll-Rand Company, and a member of the Naval Advisory Board, made the statement that the industrial importance of a country is measured by the amount of coal it consumes, because it takes coal "to turn the wheels around." The United States, Germany and England consume eighty per cent. of the coal mined and also a like amount of the iron. Per capita the United States consumes five tons of coal, England and Germany each four tons, so that this country leads the world industrially. And these two, coal and iron, are also two of the greatest sinews of war.

Mr. Saunders' whole speech on "Industrial Preparedness" was listened to with absorbing interest, for there is no more important matter before us at present. It cannot but be a matter of pride to the engineer that, with so much depending on power, he is the means through which the potential energy in the coal becomes the kinetic energy—mechanical or electrical—without which there would be practically no industry.

Let the industries, then, not forget that they are the real strength of the nation, for they are back of the army and back of the navy. No matter how many men may be available for fighting, they would be useless without supplies, and it is on the great army of workers providing the supplies that the country leans. And behind them again are the engineers.

The plan to so organize our industries that in time of emergency they could immediately take up the tasks of supplying such munitions as each is best-adapted to furnish, is one of the greatest steps so far taken to secure this country's peace and prosperity. We cannot keep out of war by shutting our eyes or turning our backs. None of those arguing against "preparedness" would want to live in an unpoliced community. The best insurance of peace is the certainty that we would be formidable antagonists.

The Value of a Title

Red-blooded men with ability to perform difficult tasks are apt to look upon titles as mere evidences of red tape, but experience shows that an appropriate designation, after all, has its uses. In a big industrial organization, for example, with a private power plant, there are sure to be various departments, each headed by a designated official, but how often the power department has no standing as a specific branch of the company tree! That is, how frequently one finds a well-maintained and efficient plant in charge of an unassuming, quiet, competent engineer who is not regarded by other department heads as in their class at all, who is next to never called into the councils of the company unless something is out of order in the service equipment, and whose requests for coöperation from other department heads are looked upon with mild indulgence, not to say indifference!

It goes without saying that no general specification for organization can be much of a success, and yet the giving of a real place in the executive organization to the chief engineer, superintendent of power, or whatever he may be called, is an exceedingly good move. The power department deserves just as much recognition when the organization family tree is planted and nursed along to productive growth as any other. Give the head of this part of the company's make-up a recognized title in the private-branch telephone directory along with the sales and advertising departments; put the title of the chief on letters bearing upon his administrative work; see to it that his office door is adequately labeled, that his business cards represent his responsible duties in the organization; and then, in the interests of company team-play, set it forth that communications from him are to be regarded by heads of other departments with the same respect and attention as their own.

These are days when the chief engineer has to be a good deal more of a man than is implied by the ability to repair a valve in the manager's private lavatory in the shortest possible order or to keep the station going without bringing it to the attention of his superiors for

weeks at a time. Putting the chief of the power department on an executive level with other heads in the main organization will not necessarily require his protracted absence from his immediate duties when problems are being discussed in conferences that do not directly affect his own bailiwick; but even extra good men are handicapped in these days of coöperation and interlacing relationships if adequate official recognition is withheld. The internal work may go along with little difference, but the lasting interest of the entire organization is very intimately bound up with a formal understanding as to executive responsibilities from the coal pocket to the shipping platform.

Determining Equipment Sizes

What shall be the policy in determining the size of power-plant equipment, whether for new stations or in connection with improvements? No more important question comes to the engineer whose advice is asked regarding designs or extensions, including under the latter comprehensive reconstruction programs.

Results at the lowest cost express the desired solution of practically every engineering problem. Costs are of two kinds—overhead and running—and if the distinction between the two is always kept in mind, specific problems become wonderfully clarified. In the past too much emphasis has been laid upon operating expenses by plant owners in proportion to the thought expended upon fixed charges. Engineers have been told too little about the capital investment in their stations, while being urged from January to December inclusive to keep running expenses as low as possible. It is high time for the plant owner to realize that the old policy of secreting investment outlays lest somebody outside the plant shall find out what the apparatus cost, is passé. A most valuable result of public-service commission regulation has been the letting of daylight upon plant construction and operating costs hitherto kept under lock and key and shown only at rare intervals as a special favor to trustworthy associates. Plants not regulated in this way might do well to adopt the same frankness of disclosure, and certainly, within the organization there is no excuse for withholding investment data from the ranking engineer.

All this simply means that the local engineer's advice is going to be sought more and more in the conduct of plant affairs, that he is going to be asked to sit at the conference table with the manager and the consulting engineer as a matter of course. In plenty of cases the outside expert will be needed to bring to the solution of the local problem the results of broader observation and wider experience, but the standards of operating men are constantly being raised and their suggestions are being taken for their real value more today than ever before. Now how does this bear upon size determination?

Obviously, to discuss sizes of specific apparatus would require a volume, and what we are trying to emphasize is the larger viewpoint, the underlying principles at issue. The forecasting of service requirements is at the bottom of the whole matter. Predetermination of load curves, of operating cycles based wherever possible on previous records with plotted projections of average tendencies, maximum and minimum tours of duty is what is needed. Then comes the consideration of combinations of sizes of present commercial units, followed by discussions with the manufacturers as to the outlook—and guarantees—for future development. First cost of units, service results elsewhere, reliability records, economies in routine work and under test, and free access to cost data of existing apparatus as well as to running expenses and repair outlays are demanded. The factor of reliability is of immense importance where large units are tentatively selected, for no matter if the economy of a larger unit is considerably better, if virtually continuous service cannot be secured from it, subdivision is to be preferred. In this connection it is a question if some companies are not running pretty close to the wind in boiler-plant selection and allowing too little reserve capacity in steam-generating units. Large boilers have their place, especially where prime movers of great capacity are involved, but ample provision for shutdown of this equipment for cleaning and repairs without forcing the remainder beyond all reason for days at a time, if not weeks, is a very pertinent consideration.

In considering the foregoing factors and in studying probable load developments, the judgment of the operating engineer in executive charge of a station is coming to be very useful. Who else is so well qualified to set the limits of usefulness of existing machinery, to specify where a single new unit, say a turbo-feed pump, should be relied upon to handle the normal day's service and how far the plant should find reserve capacity necessary? As plant equipment grows in size, the difference between types and the materials of construction affect the ultimate cost of operation more and more, and often materials suitable for low-pressure or moderate-capacity installations are found inappropriate for larger establishments. Thus it comes about that the selection of equipment sizes is a problem for the specialist in station operation to share if not wholly to determine, and the advancing professional attainments of engineers in modern plants are qualifying them more and more to take a hand in these broader questions of administration.

According to the last Government regulations for steam boilers in Ontario, a steam gage on a high-pressure boiler must have an extra connection to which to connect a test gage. Let us see How many states in the United States require this?

In the United States Navy, as on some railroads, fusible plugs and other safety devices, except safety valves, are not allowed, the claim being that they foster negligence. Well, we will always have with us, perhaps, the fellow who depends upon his shoe top to catch the coins that fall through the hole in his trouser's pocket.

There is purposely no comment with the "foreword" this week. It tells its own story and there are several lessons in it which any reader can easily pick out for himself. Of course it does *not* apply to you, dear reader, ("Present company always excepted"), but we will wager a box of good perfectos against a box of matches that everyone who reads this can think of at least one in his circle of acquaintance who never sticks in any one place long and for just the same cause that makes "John Evers" a rover. If you have an opportunity to do it kindly leave this issue around where he will see it.

Correspondence

Is Lime Good Belt Treatment?

I am much interested in F. P. Kinder's way of treating belts with lime under the caption "Vertical Belt Gives Trouble," on page 26, Jan. 4, 1916. I do not get the theory. It has been my experience that belts should not be subject to any granular treatment or to anything that dries out. It is a parallel case, almost, to the discussion carried on in *Power* some time ago on the subject of sand in bearings. One engineer, I remember, began the argument by claiming that sand was "good stuff" for bearings, and immediately protests were rained on his head from all sides.

Castor oil, I should say, would be better than lime because it is backed by better theory at least. Neatsfoot oil, also, wouldn't be so bad. But since a regular belt treatment is so much better, I would not use anything else.

I recently saw boiled linseed oil recommended as a belt treatment because it makes the surface of the belts "dry and hard." Now, "dry and hard" is just what belts should not be. W. F. Schaphorst.

New York City.

Writing Technical Reports

I read with interest the editorial reference in the Jan. 18 issue to the recently added course in technical writing at a well-known technical school. At New York University a course such as the one described has been given for the past three years. It is really a complete course in "Business English and Technical Writing." The course in business English is given during the first half of the sophomore year, and the technical writing during the second half.

The three classes of engineers—mechanical, civil, and chemical—are grouped together for the first half of the year. The textbook is one that was written for business men, and it is supplemented by each student being required to subscribe to *System*. The work consists of lectures and so-called laboratory work; the principles laid down in the lectures being put into practice in the laboratory hour, by having each student write sales letters using the information furnished in the advertisements of *System*.

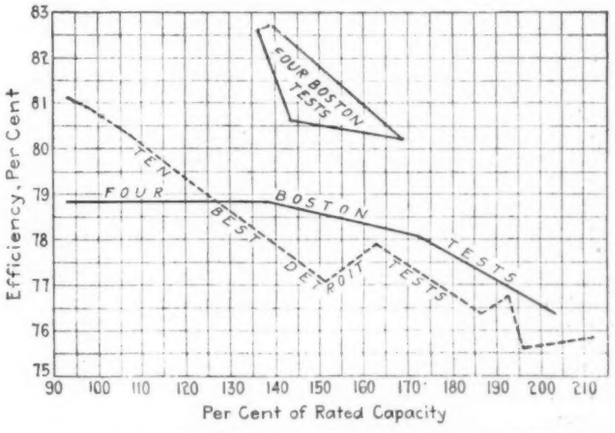
During the second half of the year, each group of engineers meets separately, because the technical writing of each group varies. There is no textbook prescribed because none has yet been written that covers the field. The mechanical engineers, however, are required to subscribe to *Power*, the civil engineers to the *Engineering Record*, and the chemical engineers to a paper of their profession. The work includes, first, practice in making abstracts from articles in the various magazines. Next, report writing is taken up; each student is required to visit power plants of some sort and to make a written report on each. Lastly, the students are drilled in specification writing.

In addition to the foregoing, we have one distinctly novel feature. One hour a week is set aside for "oral report-making." Students are assigned subjects for discussion in advance; usually they are required to investigate products advertised in their technical papers. As a rule the manufacturers are glad to coöperate and furnish information. With this information in hand and with the remainder of the class as a board of directors, each student is given ten minutes' time in which to explain his product to the board of directors and to prove its superiority. C. L. McCrea.

New York City.

Questions Boiler-Test Results

J. C. Long, of the Boston Woven Hose and Rubber Co., in the issue of Jan. 4 claims the championship for boiler-test results. His figures are nothing to boast of, for much higher figures were obtained in the plant of the Boston Woven Hose Co. as much as fifteen or twenty years ago. The superintendent obtained a record of 14 lb. of water per pound of coal, but having no confidence in his own figures, got R. S. Hale, an expert in boiler tests, to make a test, and he practically duplicated the result.



CURVES OF BOSTON AND DELRAY BOILER TESTS

Mr. Hale also disbelieved the figures and called on me to help him make another test. I sat on the coal pile all day and weighed all the coal, while Mr. Hale weighed the water and checked the weight record against that of a water meter. We got a result of 11 lb., which was reasonable.

I once tested a boiler in connection with a pumping-engine test. The feed-water record made the evaporation 13 lb. per pound of anthracite, but the surface-condenser record made it only 10 lb. Three weeks later the superintendent of the water-works had a trench dug in the boiler room and discovered an underground water pipe which conveyed hot water from the boiler to a sink used for washing purposes.

About thirty years ago a boiler in Ansonia, Conn., fitted with a furnace invented by Doctor Blanchard, gave

a record of 17 lb. of water evaporated per pound of coal. Some time afterward Professor Thurston made a test of the boiler, condensing all the steam in a surface condenser, and got a result of about 11 lb.

About three years ago there was published in *Power* the report of a test made by the United States Government engineers at the Panama Canal, which gave an efficiency of 83.46 per cent. *Power* later published my recalculations of the data given in the report, making the efficiency about 79 per cent., the error of the original calculation being due to a wrong method of computing the factor of evaporation.

The moral of all this is: when publishing the results of a boiler test always keep "probability" in view.

Seriously, Mr. Long does not give enough data of his tests to furnish a basis for a discussion of them. The missing data are: Kind of boiler and furnace; stoker- or hand-fired; duration of test; kind of coal; analyses of the coal and of the flue gases; heat balance. He also should explain, if he can, why the boiler gave higher results than were obtained by Doctor Jacobus in the Delray (Detroit Edison) tests, in which all the conditions were most favorable, the air supply being regulated in accordance with the results of the gas analyses. The following table gives a comparison of the 10 best results of the 16 Detroit tests with the 8 tests reported by Mr. Long.

Per Cent. of Rating		Efficiency		Per Cent. of Rating		Efficiency	
Detroit	Boston	Detroit	Boston	Detroit	Boston	Detroit	Boston
....	93.4	....	78.87	151.3	....	77.07	....
93.9	....	81.15	....	162.9	....	77.85	....
98.6	....	80.98	....	....	169.0	....	80.18
107.8	....	80.28	....	....	173.4	....	78.00
121.2	....	79.24	....	185.5	....	76.42	....
....	135.3	....	82.60	193.3	....	76.73	....
....	138.3	....	78.90	195.7	....	75.57	....
....	139.1	....	82.74	....	204.4	....	76.47
....	143.5	....	80.61	210.1	....	75.84	....

The sketch shows the plotting of these figures, and it clearly indicates that the four Boston tests showing over 80-per cent. efficiency had something wrong about them.

Montclair, N. J. WILLIAM KENT.

Cylinder Lubrication Question

I would like to see a discussion and a reasonable conclusion as to the quantity of cylinder oil required to lubricate a steam engine of a given size and also the grade of oil best to use. The amount of cylinder oil we have used for the last five years in one 22x20-in. Brownell engine operating at 200 r.p.m., steam pressure 110 lb., in 11 hr. is 1½ quarts at 30c. a gal.; another, 19x20 in., 225 r.p.m., 1 quart per 8-hr. run; another, 18x18 in., 225 r.p.m., 90 lb. steam, 1 quart in 8 hr.; one Russell engine, 19x20 in., 200 r.p.m. 90-lb. steam pressure, 1 quart in 8 hr. All the engines are direct-connected to generators.

The company, thinking we were using too much oil, sent an expert, and he has reduced the cylinder oil on the Brownell 18x18 and the Russell engine to 1 pint in 8 hr. The old single-valve Russell engine after a 2-hr. run got to racing badly and speeded up. I told the expert that the engine was not getting enough oil, but he said it was getting plenty of it and was running nicely and that if the valve ran hard, the engine would slow down, as it would take more time for the valve to travel, but if any racing occurred, it could be checked by closing the throttle valve until the governor took its position again. I decided that I had learned enough from him, so if the company is willing to pay several dollars more in fuel daily on account of a leaky valve and have the engine rebored every 12 months, besides the other dangers, to save 25c. worth of oil, "I should worry." I have been working around engines for 28 years and have never seen an engine ruined on account of giving it too much oil. This scientific lubrication thing has "got my goat," and a discussion of the subject would be very interesting. If a crank makes the world go around, a little oil will make it turn easier and last longer.

Yours for a little more cylinder oil,

Dewmaine, Ill. JAMES BAUDINO.

Testing Pressure Gages in Refrigeration Plant

There appears in the Oct. 26 issue a letter by Gay A. Robertson, on testing ammonia pressure gages by reference to ammonia tables. The method described is all right if there is no air or other permanent or incondensable gases in the system.

If such gases are present, the temperature of the saturated ammonia vapor in the condensers will not correspond to the temperature of the condensing water, and since this is true, it becomes necessary to first make sure that all permanent gases are removed before attempting the test recommended by Mr. Robertson.

Jacksonville, Fla. C. T. BAKER.

Diesel Engine Economy

In the Jan. 18 issue I read with interest Mr. Wentworth's communication relating to the article, published last November, describing the Diesel engines of the McIntosh & Seymour Corporation. It strikes me, however, that an incorrect view is taken of the questions of simplicity and economy and their interdependence, in the design of Diesel engines.

When Mr. Wentworth is told that the highly economical Diesel engine is a simple one, and that simplicity is made a special feature of the McIntosh & Seymour engine, he asks, "Why the cry for simplicity?" Well, the Diesel engine is either a commercially successful piece of machinery, welcomed by practical engineers, in the highest sense of the word, or it is a scientific toy, all very interesting, but for economic reasons entirely unavailable for power production in an industrial plant. If the engine is not a success from a business standpoint, it is an engineering failure, though its fuel efficiency be the sensation of the age. Now simplicity makes for commercial success because it implies both cheapness in manufacture and ready acceptance at the hands of the operating engineer.

I should be the last to deny that the matter of economy is of minor importance—in the Diesel engine it is of course the main point. However, calculations will show that if the initial cost of a Diesel engine can be decreased by 10 per cent., the fuel consumption can be allowed to increase 10 per cent. without materially changing the over-all efficiency of the engine, measured in dollars and cents.

In the letter referred to, it is pointed out that whereas the steam plant can show but 12 per cent. thermal efficiency, the Diesel engine can turn 25 per cent. of its

thermal input into brake horsepower. This fact by itself is of little significance to the manager of a power plant because the first prime mover burns coal and the second burns oil. Should the price of oil suddenly advance to twenty times that of coal, Diesel engines would no longer be built, though their fuel consumption would be unchanged. The only reason Diesel engines are made and sold is because in a great many cases they prove to be the cheapest source of power. NELSON OGDEN.

Auburn, N. Y.

Boiler Tube Quickly Replaced

With regard to the quick and cheap repair job described by Mr. Ellis in *Power*, Oct. 26, p. 594, I think he did well; but as the wages were low, conditions were in his favor. Last fall we retubed the front drum of our Stirling boiler, which is 4 tubes deep and 16 tubes wide—64 tubes 3¼ in. diameter. We did this work in 2¾ days of 10 hr., counting the time of repairing all the baffles, at a cost of about 50c. per tube for labor; and as the wages here are 30 per cent. higher than on the job Mr. Ellis described, I think we did well.

For quick replacement of a tube I believe we hold a good place. Last summer a 4-in. tube in a B. & W. boiler started a bad leak at 12 o'clock noon, and as it was not safe to run it, we decided to replace it at once. As it was necessary to have this boiler in operation by evening, we worked rapidly and had a new tube in and the boiler on the line at 4:30 p.m. We had to enter the furnace and the combustion chamber to get the old tube out and the new one in. Who has done better?

New Brighton, Penn. EDWARD HORSFIELD.

Difficulty with Suction Line

That the suction-line difficulty described by Mr. Arnois in the issue of Dec. 21, page 867, may be due to the closing of the inlet by trash seems quite probable from the vacuum obtained in the suction line, and it hardly appears possible in any other way except by a valve being partly closed or a strainer with too small openings.

Assuming the inlet to be stopped at the supply well, the 8-in. pump should be the last to give trouble instead of the first. I should assume that the stoppage was at the 24x18x8-in. tee near the 8-in. pump or in the line between this tee and the pump and that the vacuum was tested between the tee and the pump; so the remedy of course would be to remove the obstruction.

Another possible cause of the trouble is the 36-in. pipe partly filling with air followed by a surge in the line by which the air would come down into the smaller pipes in a large volume and stop the flow of water through the pump. A small leak should cause no trouble if the pump is handling near its rated capacity in gallons per minute and air does not reach the pump in large quantities at one time. But in the case shown, a small leak in the 36-in. pipe would fill it with air down to the top of the 24-in. pipe or, with only one or two pumps running, to the top of the 14-in. pipes, and starting another pump would suddenly increase its volume until it entered the 8-in. pump.

As to starting the pump, I should suggest that if a connection were made on the suction where it passes around the shaft—that is, as near as possible to the axis of the impeller—and the ejector connected at this point, the pump could be started in any manner desired, and as long as the jet was running the pump would operate, if up to speed and air was not allowed to enter through the discharge line. The jet, connected in this manner, will remove the air near the center of the impeller, where it sometimes collects and prevents the pump from working properly. T. R. MARTIN.

Columbus, Ohio.

I was interested in the letter by Mr. Arnois in the issue of Dec. 21, 1915, page 867, as I have known cases where the suction-pipe intake has become stopped up with ice, sand, mud or trash. As a general rule it can be removed or partly so by flushing back—that is, by letting water from the discharge side or some other source into the suction pipe to wash the foreign matter out.

Most plants are not arranged for flushing, and strainers must be cleaned either by getting at the intake and removing the foreign matter by hand or by flushing back, by letting air into the suction pipe to let the water in it flow back. Or if there is an available supply of water on the discharge side and the pumps are reciprocating, a sufficient number of valves in the suction and discharge chamber may be removed to let a good flow of water through. The flow of water should be regulated by the discharge valve by a pressure gage that should be connected to the suction pipe so as not to get more than the pipe will stand—often much less than the discharge line.

Kansas City, Mo. LAWRENCE KJERULFF.

Handling the Superheater

We have several Stirling boilers in our plant with Babcock & Wilcox superheaters, and as there are no provisions made for flooding them, the question has come up as to the proper way to get up steam.

Should the boilers be fired up fast or slow, or should they be fired light until a pressure of 25 or 30 lb. is raised and then fired heavy? We are often called upon to get an extra boiler on the line on short notice and for that reason would like suggestions from others.

JAMES BLANCHARD,

Massillon, Ohio. Massillon Electric and Gas Co.

[The usual practice is to bleed the superheater.—Editor.]

Bronzes for Turbine Blades

I note W. Maclean's article on turbine blades on page 904 of the Dec. 28, 1915, issue. Mr. Maclean says he used bronzes, and by that I take it he used the first bronze that came to hand, without knowing its composition and the percentage of the different elements. While the old saying, "pigs is pigs," may hold good for some things, it is not true of bronze. "Bronze is bronze" only until we decide what it is to be used for, then it becomes a question of phosphor, manganese, nickel, carbon, delta, etc. One bronze may be best for bearing and wearing surfaces, but would not be the proper one where strength is required, and vice versa.

Bronzes of alloyed copper, zinc, antimony and lead are better suited for bearing surfaces, while bronzes of copper, zinc, nickel, iron and tin are better where the conditions require strength, freedom from corrosion, e-

The following are the United States Navy specifications for turbine buckets:

Material	Percentage Copper	Tin	Zinc	Iron	Lead	Miscellaneous
Phosphor bronze..	80 to 90	6 to 8	13.44 to 344	0.06	0.2	Phosphorus, 0.3
Manganese bronze.	57 to 60	0.75	37 to 40	1.00	...	Manganese, 0.3 Aluminum, 0.5
Monel metal*.....	33	....	.....	6.50	....	Nickel, 60 Aluminum, 0.5
Composition†	53 to 56	....	45 to 42	....	0.5	Nickel, 1.5
Cupro-nickel.....	79 to 81	....	.... .	0.75	....	Nickel, 20.25 to 18.25

* For turbine buckets monel metal is undoubtedly the best suited of the copper alloys, usually commercially composed about as follows: Copper, 26.5 per cent.; nickel, 72; iron, 1.5. It is ductile and flexible, has a high resistance to corrosion and relatively small contraction and expansion under temperature changes; its tensile strength is from 70,000 to 80,000 lb. per sq.in. † Similar to commercial tobin bronze, the composition of which is: Copper, 50 to 65 per cent.; zinc, 49.9 to 30; iron, 0.1 to 5.

For turbine buckets I would class the alloys about as follows: Monel metal, cupro-nickel, composition (tobin or delta bronze) manganese bronze, phosphor bronze.

Mr. Maclean probably used a bronze with only copper, zinc, lead, antimony and tin, which is well suited for bearings, but has not the strength of the copper, nickel, iron, phosphor, manganese alloys.

West Orange, N. J. GEORGE W. JAGER.

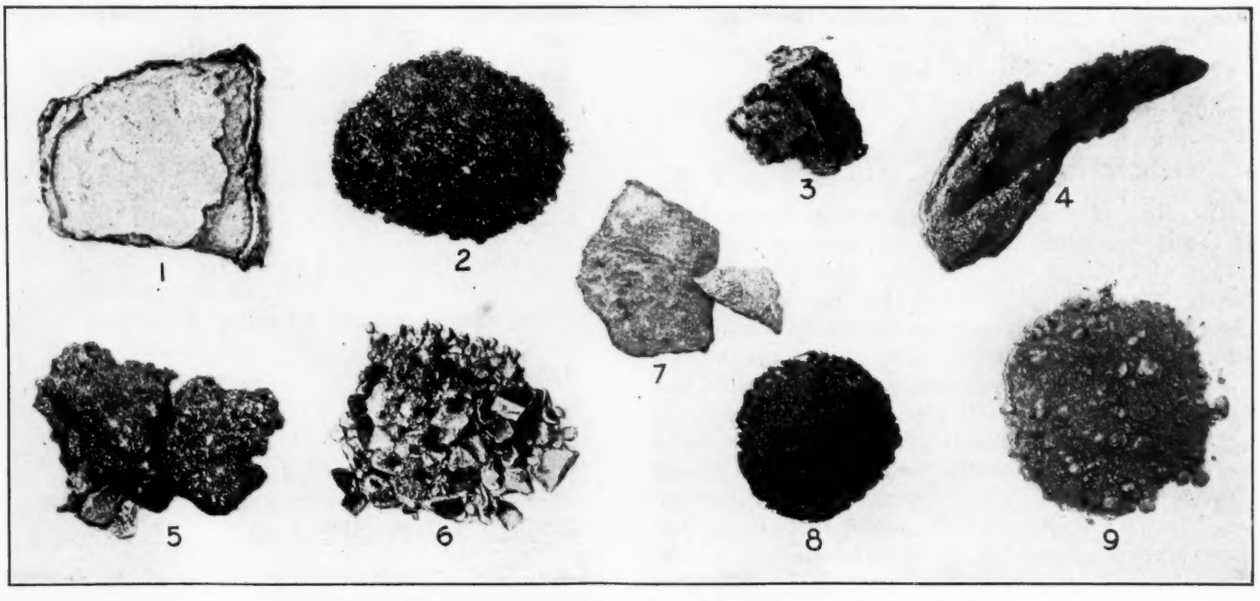
Can the Formation of Soot Be Prevented?

A letter by W. F. Schaphorst, in the Dec. 14, 1915, issue of *Power*, on the subject of soot formation and its prevention by complete combustion, expresses a belief that is quite prevalent. When Charles De Ved came to New York to undertake the sales of Vulcan soot cleaners, he found that engineers said that they were either getting no soot because they were burning anthracite, or that they were getting such good combustion that little soot formed with bituminous, and that could be easily cleaned out.

Before anything could be done in the way of introducing the cleaner, a study was made of the soot problem. Mr. De Ved, and later myself, found that soot in many cases was not real soot at all, that it was largely ash. With anthracite coal it was principally ash; with bituminous coal it was a large percentage of ash and the rest was true soot, or amorphous carbon. The poorer the boiler setting and combustion, the greater was the percentage of real soot in the mixture. Specimens were taken for study and analyses, and some are shown here in Figs. 1 to 9.

Soot, as found in boilers, is not pure soot at all; often it is not even black. If fuel were burned with the requisite quantity of air and there were proper mixing of air and the volatile gases, the combustion would be complete; as in a Bunsen burner, for example, and soot formation would not occur. It follows then that if a furnace of large volume were practical and the stoking, whether hand or mechanical, were efficient at all times, or if anthracite coal, low in volatile matter were burned, there would be little or no formation of true soot. But even if ideal conditions of combustion were continuously maintained and no soot—that is, amorphous carbon—formed, the heating surface would become covered with a heat-insulating coating formed largely of ash.

This constituent of the so-called "soot" often forms the greater part of the deposit, as evidenced by the color, which may be grayish, green, red, brown or even white. The character of these deposits varies greatly, being in some cases a heavy, gritty dust, almost always containing some percentage of true soot or carbon. These deposits often fuse at low temperatures, and the effect of the coating is cumulative, first by insulating the tube and causing the gas temperature to rise and then, owing to this higher temperature, fusing and forming heavier and more impenetrable coatings with consequent higher gas temperatures, leading to further fusing and in some instances bridging over from tube to tube with a clinker formation. This checks the draft and reduces the capacity, and when the formation occurs on superheater tubes, diverts the gases with consequent reduction in superheater capacity.



CHARACTERISTIC APPEARANCE OF HARD- AND SOFT-COALSOOT

Fig. 1—White, fluffy anthracite. Fig. 2—Black, flaky, slate-like anthracite. Figs. 3 and 4—Bituminous clinker formation from gas passages. Fig. 5—Hard, brittle, reddish-brown deposit. Fig. 6—Light, powdery deposit, semibituminous. Fig. 7—Scale-like grayish-brown deposit, semibituminous. Fig. 8—True soot of lampblack, semibituminous. Fig. 9—Velvety deposit of ash and soot, semibituminous

Anthracite coal contains only 3 to 7½ per cent. volatile matter and burns with little or no formation of soot. But many anthracite coals are high in ash, part of which is picked up and carried along by the draft and clings to the tube surface, as snow clings to the trunk and limbs of a tree. Specimen Fig. 1 shows soot from anthracite coal of 16 per cent. ash. This soot is white, soft and powdery and is so light that it floats in the air. When crushed in the hand it resembles talcum powder. It will adhere to a surface like the outside of a boiler tube and gradually accumulates to a considerable thickness. This specimen was taken from a Stirling boiler in a large steel works. Although the boiler tubes are substantially vertical, the deposit coats the tubes and accumulates. The chemical analysis of this soot corresponds with the ash analysis and is given here: Iron oxide, 5.09 per cent.; silica, 69.15; alumina, 18.22; lime, 0.65; magnesia, 0.54; sulphur dioxide, 1.05; various alkalis, 5.05.

Another specimen of soot formed when burning anthracite coal is shown in Fig. 2. This deposit is flaky, the particles being mostly small flat disks of slate.

With bituminous coals having volatile matter as high as 30 to 40 per cent. and ash as high as 20 per cent., one naturally expects that the soot deposited on the tubes would be a combination of true soot and ash.

Where combustion is complete there should be no unburned carbon to make smoke or soot, and the soot on the tubes should be principally ash and clinker. On the other hand, if the stoking is only slightly inefficient and the air supply unevenly distributed throughout the coal, a black sooty deposit should be found on the tubes, due to the chilling effect of the comparatively cool tubes on the suspended amorphous carbon particles in the gases. Thus the character of the soot is a good indication of the furnace efficiency, and as a rule the visible smoke increases directly as the decrease in furnace efficiency.

Fig. 9 shows a deposit from the tubes of a Babcock & Wilcox water-tube boiler fired with Shawmut coal. This soot is a gritty substance made up largely of ash, the percentage of carbon being comparatively small. In contrast the soot of Fig. 8 taken from another boiler of the same type, is black, being a combination of ash and true soot. Fig. 9 contains no true soot; Fig. 8 contains a large percentage of soot, and a pinch taken in the finger leaves typical soot marks. The coals in each case were nearly identical grades of semibituminous. The difference in formations is explained by the fact that better combustion is obtained in the first plant, due perhaps to more careful operation and to much higher boiler settings. Another specimen of deposit with semibituminous coal is shown in Fig. 6; it is light, powdery and fluffy and practically free of all traces of true soot or carbon.

The deposits so far considered may be termed primary or nascent deposits. If these soots are allowed to accumulate, new and complex deposits are formed. As the temperature of the gases becomes higher, owing to the insulation of the heat-absorbing surface, the carbon burns out in part and the ash fuses into a clinker. This action is progressive and cumulative, because the formation of the clinker itself further insulates the tubes and raises the temperature.

Finally, the clinker from one tube arches across to that being formed on another, and large continuous clinker formations eventually bridge the gas passage. Such formations are shown in Figs. 3 and 4. These were taken from about the center of the first pass of a water-tube boiler fired by an overfeed stoker with bituminous coal. They are hard, brittle and porous and resemble slag of reddish color.

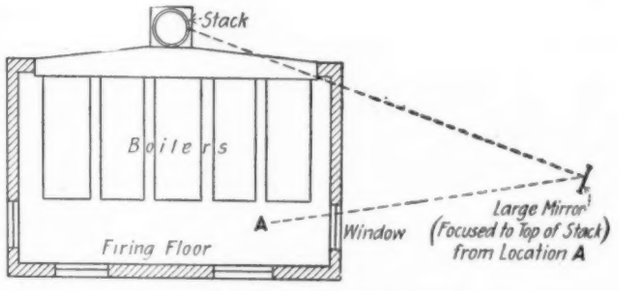
Another secondary soot formation is shown in Fig. 5. This is a hard, brittle deposit, the particles being cemented rather than fused together.

This formation is found only in the tubes near the furnace, and it is believed that certain of the constituents of the ash have the necessary adhesive or cementing power to cause the honeycomb deposit.

JOSEPH KISSICK,
New York City. De Ved-Kissick Co.

Smoke-Stack Periscope

As a rule the operator cannot observe when the stack is smoking unless a trip is made outside of the plant, and this is often quite inconvenient. In some plants this can be overcome by using what might be called a "stack periscope," consisting simply of a large mirror placed outside the boiler room and focused on the top of the stack in such a way that the image is reflected into the boiler room through a convenient window. The illustration shows how this is accomplished in a typical plant, the image showing the condition at the stack outlet so that it can be observed at any time.



SINGLE-MIRROR PERISCOPE

In situations that do not permit of such direct observation, two or more mirrors may be used to reflect the image from one to another and to the point of observation.

The value of such an arrangement is quite apparent, since it will show the fireman when his firing is producing excessive smoke and waste. The principle can also be employed in observing exhaust outlets or any other equipment installed away from the main plant.

Philadelphia, Penn. W. SAILES.

Stroke Counter on Feed Pump

Referring to the letter, "Observations While on the Road," on page 905 in the issue of Dec. 28, 1915, describing a revolution counter connected to a boiler-feed pump, this device might not give a very accurate result under all circumstances, but given favorable conditions, it has its good effect not only on the fireman, but also on the general operation of a power or heating station. It will give a close account of the amount of water fed

to boilers, as shown by the following test of a counter connected to a 14x9x16 double-acting outside packed plunger pump used for boiler feeding.

The displacement of the plunger is 4.4 gal., equal to 36.65 lb., of water per stroke. In testing this pump for slippage and short stroke, a barrel was placed on a scale and a hose connected from a tap in the pump discharged into the barrel, and a uniform pressure was maintained at variable speeds. The pump was run above maximum and also below minimum speed for supplying boilers. At 15 strokes per minute against 135 lb. pressure, the pump delivered 36.58 lb. per stroke. This allows only 0.018 per cent. for slippage. At 5 strokes per minute against 135 lb. pressure, it delivered 36.08 lb. per stroke, with a slippage of 1.55 per cent. In regular service the temperature of feed water is 165 deg. F. with a suction head of 4 ft. The pump is operated at full stroke and the valves are in good condition, and as tests are made frequently, the counter is nearly as accurate as many hot-water meters on the market. This pump is operated in a heat, light and power station where the exhaust and some live steam is used for central heating, and nearly all the efficiency performance is figured from this little stroke counter that cost about a dollar, is mounted on a board and receives its movements from the valve stem of the pump. The table gives an example of what this counter shows in regard to condensation in an underground heating system with old and inefficient covering.

Date Dec.	Total Steam Metered in System by Condensation Meters per 24 Hr.	Feed Water Entering Boilers per 24 Hr.	Percentage of Condensation Lost in Steam Mains	Temperature of Atmosphere at 7:00 A.M. Deg. F.
23	232,000	343,000	32	10
24	252,000	350,000	33	12
28	285,000	394,000	27	6
29	256,000	371,000	31	8
30	310,000	399,000	22	—2
31	325,000	413,000	21	—4

During the peak load, with sufficient exhaust steam and an economical load on the units in service, the counter registers 36.5 lb. of water per kilowatt hour recorded by the wattmeter and this checks up with the performance of the units. The work of this counter is respected to such an extent that from eight to ten thousand dollars will be spent this year on an improved covering for the underground steam mains.

Bismarck, N. D. C. P. Larson.

Exciters Would Not Parallel

At the plant where I am employed, there are two exciter units—one a 7-kw. belt-driven and the other a 14-kw. motor-driven exciter. The smaller one was cut out one day in order to repair the belt, and later, when the operator proceeded to parallel it with the 14-kw. machine in the usual way and attempted to regulate the rheostat so that the load would divide equally between the two, the belted exciter would motor and throw its belt.

It was puzzling for a few moments, but an examination of the rheostat revealed the trouble. It had worked loose at the screws fastening it to the switchboard and had got out of place enough so that the sliding contact lever touched only on half the contacts. The rheostat was then fastened securely in place and the exciter cut in without further trouble. Edward M. Keys, Jr.

Montesano, Wash.

Cleveland Municipal Plant

In the issue of Dec. 28, 1915, figures were given from a recent municipal bulletin, offering conclusive operating and cost figures to prove the success of the undertaking.

The "good showing" of the Cleveland municipal plant does not stand analysis. It is based on the neglect of the essential element of provision for depreciation of the city's investment, a common and very easy method of making two ends meet, or of demonstrating superiority to private operation which would not be allowed to neglect this necessary item of earning capacity.

The statement issued shows a sale of 89 per cent. of the generated product at an average price of 2.09c. The investment by the city had been, to the date of Aug. 31, 1915, $2,351,910. The fixed charges for the 8 months, January to Aug. 31, were:

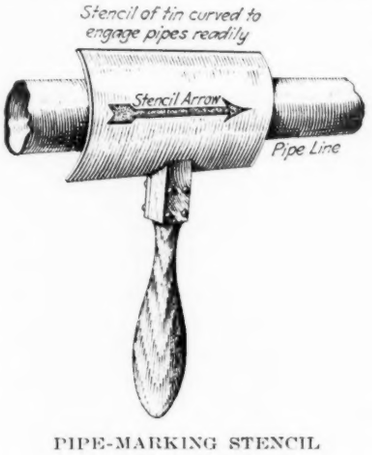
Interest and sinking fund at 8 per cent. per annum		$125,275
Depreciation should be added, say 4 per cent		62,716
Total		$187,981
Per kilowatt-hour sold	1.25c.	
Operating costs and maintenance		181,735
Per kilowatt-hour sold	1.21c.	
Total cost	2.46c.	
Total sale price	2.09c.	
Loss per kilowatt-hour sold	0.37c.	
Deficiency in 8 months' operation		$55,916
Instead of a profit of		$6,789

It would also be proper for the public to be informed if the "total operation and maintenance" cost includes utilization, administration and commercial expenses. As it stands, the good showing looks very dubious. Let us have all the facts and figures before we accept it.

New York, N. Y. Reginald Pelham Bolton.

Distinguishing Pipe Lines

Marking a pipe line to indicate the fluid in it and the direction of flow may be accomplished by painting on the pipe an arrow pointing in the direction in which the medium flows and of a distinguishing color to suit. This will be found convenient when the valves are to be turned on or off in out - of - the - way places. The arrow can be cut out of a piece of tin or cardboard, forming a stencil, as shown in the illustration, and the pipes can be easily stenciled at frequent intervals along the line and at points best suited. The colors suggested are as follows:



PIPE-MARKING STENCIL

Red arrow.....Fire line
Blue arrow.....Cold water-supply lines, etc.
Yellow arrow.....Hot water
White arrow .....Steam
Violet arrow .....Gas
Brown arrow.....Exhaust. Steam-line drains
Aluminum arrow...Sewer and downspouts
Green arrow.....Air pipes

Stencils with the arrow and the words "steam," "air," etc., are, by some, considered preferable to the colors.

Washington, D. C. A. P. Connor.

Inquiries of General Interest

Running Motor with Lower Voltage—Will a 125-volt direct-current motor run satisfactorily on a 110-volt circuit? W. N. B.

The motor will run at a slightly reduced speed, but if it is desired to run at the normal speed it will be necessary to insert some resistance such as a rheostat in series with the shunt field to compensate for the decreased voltage.

Double Ports of Duplex-Pump Steam Cylinder—Why is each end of the steam cylinders of a duplex pump provided with two ports? R. T.

The outside ports, or those next to the heads of the cylinders, are the steam ports and the others are the exhaust ports. By having the ports thus arranged, the exhaust ports are covered by the piston before the end of its stroke and whatever steam may remain in the cylinder is compressed and acts like a cushion during the remainder of the stroke.

Removing Oil from Leather Belting—How can oil be removed from leather belting? H. B.

Oil can be removed by soaking the belting in baths such as gasoline, for taking up the oil, but the treatment is not recommended unless practiced by expert belt makers, as liquids that dissolve the oil are likely to injure the texture of the leather and loosen the cementing of the laps. In most cases a sufficient quantity of oil can be removed to render the belt serviceable by packing it in dry sawdust for several days.

Estimating Approximate Capacity of Barrels—What is the rule for estimating the number of gallons contained by a barrel? C. R.

The approximate number of gallons contained by a barrel of ordinary proportions may be found by multiplying the product of the squares of the mean diameter and length (taken in inches of inside measurement) by 0.0034. The mean diameter to be taken is half the sum of the head and bung diameters.

Inside-Packed Pump—What is an inside-packed pump? R. N.

The terms inside- or outside-packed are usually employed with reference to the arrangement of the packing of plunger pumps. An inside-packed plunger is one having the gland of the plunger packing placed on the inside of the cylinder head or wall of the pressure chamber through which the plunger works, while an outside-packed plunger is one having the plunger-packing gland placed outside of the cylinder, as in ordinary piston-rod packing.

Relative Speeds of Engines—If the speed of an engine is 205 r.p.m., and another engine, alongside, runs enough faster to come to the same position of crank once in 23 sec., what is the percentage of difference in speed? T. D.

During 23 sec. the first engine would complete $\frac{23}{60}$ of 205 = 78.588 revolutions, and as the other engine would make one more turn in the same time, its speed would be $\frac{1}{78.588}$, or 1.27 per cent. greater.

Unsymmetrical Indicator Diagrams—Considerable trouble has been experienced with an automatic engine in obtaining equal-size indicator diagrams from opposite ends of the cylinder for different loads. Is this generally true of such engines? J. C. L.

Inequality of diagrams, except for the particular load for which the diagrams may have been balanced, is true of diagrams taken from engines equipped with nearly all types of variable-cutoff valve gears, due to variation in angularity of the connections with change of cutoff. For best running conditions the valve and valve gears should be so set as to obtain the desired symmetry of diagrams when the engine is developing its average load.

Loss of Water Level in Cast-Iron Sectional Boiler—What may be the cause of present greater loss of water than during the former heating season, from a cast-iron sectional boiler used in a low-pressure steam-heating job? No leakage is discernible from the boiler or its blowoff, or from pipes, valves or radiators. D. A. B.

There may be greater loss of steam than formerly from the radiator air valves, but if that is not the case, the boiler-water level may become lowered by the unobserved discharge of steam from the steam space into the flues through a crack in one of the sections. In a boiler of this kind, cracks are likely to develop from expansion after rust has accumulated between the sections during a season when the boiler has been laid up. By removing the boiler covering, drawing the fires promptly and closing the stack damper, inspection for such leaks can be made without serious interruption in the use of the boiler.

Quality of Steam from Throttling Calorimeter—In using a throttling calorimeter for testing the quality of steam generated at 125 lb. boiler pressure, the pressure of the steam in the superheating chamber of the calorimeter was about 15 lb. absolute, and temperature 260 deg. F. What was the quality of the steam generated and the percentage of moisture? F. W. S.

The formula for computing the quality of the original steam is:

$$q = \frac{H + 0.48\ (t_2 - t_1) - h}{L}, \qquad (1)$$

in which

q = Quality of the original steam;
H = Total heat of a pound of saturated steam at the pressure that existed in the calorimeter;
0.48 = Specific heat of superheated steam as commonly taken for pressures near that of the atmosphere;
t_2 = Temperature of the steam in the superheating chamber of the calorimeter;
t_1 = Temperature of saturated steam at the pressure existing in the superheating chamber;
h = Heat of one pound of the liquid entrained in the original steam;
L = Latent heat of a pound of the original steam.

From the observations and the steam table we know that $H = 1{,}150.7$ B.t.u., $t_2 = 260$ deg. F., $t_1 = 213$ deg. F., $h = 324.6$ B.t.u., and $L = 867.6$ B.t.u.

Substituting the values in (1) gives

$$\text{Quality} = \frac{1{,}150.7 + 0.48\ (260 - 213) - 324.6}{867.6} = 0.978,$$

or 97.8 per cent.

Therefore there was 100 — 97.8 = 2.2 per cent. of moisture.

Errors Made in Application of Indicator—In obtaining indicator diagram of an engine, what errors are most likely to be made in application of the instrument? R. J. P.

Serious errors are introduced from improper design, construction or condition of the reducing motion; vibrations of the mechanism of the indicator from rough operation of the reducing motion or undue vibrations due to inertia of the indicator-pencil motion from using too weak a spring. Frictional resistances in the instrument from improper adjustment and "sticking" from dirt or from improper lubrication are faults more frequently due to untidiness and oversight than to ignorance on the part of the operator. Faulty connections to the cylinder, such as too small or too long pipe connections, cause the indicator pressure to lag behind that in the cylinder, usually resulting in too large mean effective pressure of the diagram or introduction of error from condensation or by unduly increasing the clearance volume of the engine cylinder. Failure to take up lost motion in the piston connections and joints of the pencil mechanism; stretching of the cord causing imperfect proportions of length of diagram; too great pressure on the pencil while taking the diagram, causing it to trace above the true mean line of pressure in an expansion line, and below the mean line of compression—these are errors likely to be made by beginners. Failure to warm up the indicator and have the instrument and connection clear of water and cocks wide open at the time the diagram is taken and errors in determination of the scale or "number" of indicator spring employed are mistakes that are quite frequently made by experienced operators.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Softening Water With Permutit*

By S. B. Applebaum†

SYNOPSIS—The Permutit exchanges sodium for the calcium and magnesium in the water, taking out practically all the "hardness." The softening substance is not dissolved, and for restoring its efficiency, only common brine is required.

The clouds formed by the evaporation of the sea by the sun's rays contain pure water. As these clouds condense and the rain falls, oxygen and free carbonic acid are absorbed from the air. When the rain reaches the earth, part runs off and forms the streams and rivers and another part enters the earth to form the ground water of wells and springs. The surface waters carry in suspension the clay, sand and mud washed from the banks and beds of the streams. The ground waters pass through rocks, and the free carbonic acid present assists in dissolving the mineral impurities from these rocks. When limestone is encountered by either the surface or ground water, calcium and magnesium salts go into solution in the water. The mud held in suspension and the calcium and magnesium salts held in solution are the scale-formers.

The magnesium salts are particularly injurious when they form scale, as they split up at the high temperatures existing where the scale and boiler shell make contact, and liberate free acids which attack and corrode the boiler walls. Scale of course causes an economic loss due to heat lost in shutdowns for cleaning and because of poor transmission through the tube and scale. The thickness and the characteristics of the scale influence the extent of the coal wasted. The University of Illinois in 1908 ran a test on a locomotive of the Illinois Central R.R. and found a loss of 10 per cent. in coal with the particular hard scale ⅛ in. thick that was formed. A Permutit filter, softening the water for the boilers of the water-works plant at Springfield, Ohio, has effected a coal saving of 20 per cent. Springfield water is very hard and therefore forms considerable scale.

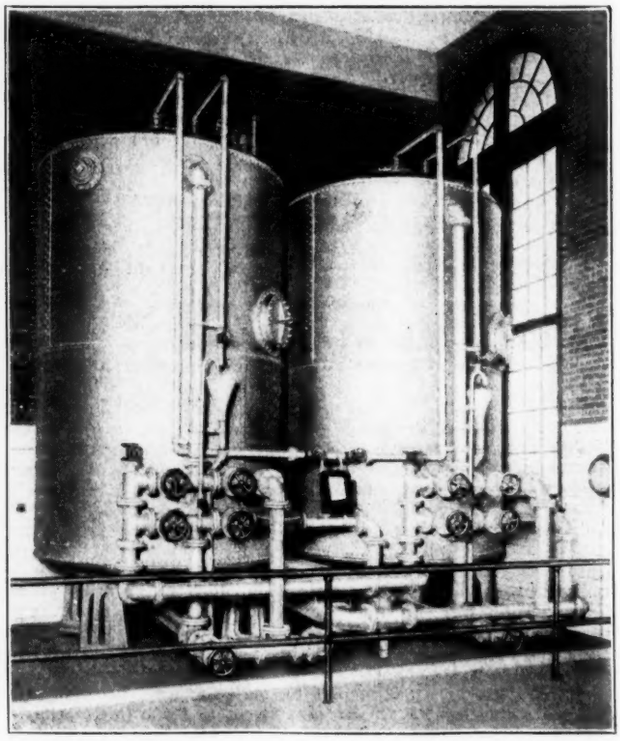


FIG. 1. PERMUTIT PLANT, UNION STOCK YARDS

*From a lecture before Newark, N. J., No. 3, N. A. S. E.

†Chemical engineer, the Permutit Co.

There are practically only three methods of treating boiler feed-water in use: By transforming the scale to mud inside the boiler; by reducing the amount of scale-forming salts in the water outside of the boiler, and by eliminating all these scale-formers outside the boiler—in other words, by using compounds, lime-soda softeners and Permutit filters respectively.

The compounds on the market may be roughly divided into three classes: Those that act chemically with the water and form precipitates that produce a lighter, more porous scale than the original water would deposit; those that act mechanically on the little particles or crystals of scale as they begin to form, surrounding them with a slippery film, preventing their cementing together; those that act mechanically, as in the second class, and chemically, breaking up scale already formed.

The compounds of the first class usually consist of soda-ash, tannins, caustic soda and some acids. In the second class are slippery elm, ground bone, potatoes, starch, fats and vegetable oils. With these two classes care must be taken that they do not form a large lump or pile on the plate and cause the latter to become overheated. The sludge or precipitates thrown down inside the boiler must be blown out as required for the same reason. The compounds of the third class consist of combinations of substances from the first two classes.

In a small plant where the boiler construction is simple and of large dimensions, where there is no room for a water softener and where coal is cheap, there may be justification for the use of compounds. But in all other cases, where these conditions do not hold, where clean boiler surfaces are essential and a shutdown to clean out the sludge produced would involve a serious loss, advanced boiler practice favors the treatment of the water outside the boiler. In at least one large central station in the Middle West all make-up water is distilled to insure against scale.

ESSENTIALS OF LIME AND SODA SYSTEMS

Nearly all are familiar with lime and soda as water softeners. There are in general two types of lime-soda softeners—the intermittent and the continuous. The intermittent system provides for several large tanks: In one the incoming raw water is being treated with the chemicals; at the same time in another tank the treated water is standing quiet to allow the precipitates to settle; and from a third tank, after thorough settling the water may be drawn for use. This system should be used only where space is cheap. The continuous system provides for the treatment of the water in one tank at a uniform rate continuously, raw water coming in and treated water going out. It consists essentially of three parts: Chemical tanks and a feed regulator to control the addition of the chemicals to the incoming raw water; a large settling tank where the precipitates formed are allowed to settle; and some form of filter to remove the precipitates that do not settle, but that tend to come over with the softened water.

The settling tank is generally arranged so that the incoming raw water receiving the chemicals at the top falls through an inner central tube and then rises slowly on the outside of this downtake. The filter may either be placed inside the settling tank at the top so that the settled water passes up through it, or it may be in a separate closed shell attached to the outlet pipe of the settling tank.

The lime-soda process does not eliminate all the scale-forming salts, but removes only part of them. The precipitates formed are themselves partly soluble in water, and it is therefore chemically impossible to reduce the hardness below 1 to 5 gr. per gal. Magnesium salts are particularly hard to remove, and with waters high in magnesium, lime-soda plants rarely give satisfaction. As every chemical reaction to be carried far enough along requires an excess of the driving reagents, it is necessary to add an excess of lime and soda-ash in amounts depending on the varying composition of the raw water. These chemicals, being caustic and soluble, leave causticity in the treated water.

Zeolite is a mineral of the family of hydrous silicates, and Permutit is the trade-name for zeolites used in water-softening. The zeolite having the greatest efficiency is at present artificially produced from raw materials consisting of clay, feldspar, soda-ash and pearlash. The material resembles broken pebbles, but under the microscope is seen to be very porous, exposing considerable surface, which of course makes rapid the chemical reactions. Permutit has the property of automatically eliminating all hardness from the water passing through it. It is a process of exchange, the calcium and

magnesium in the water being replaced by the sodium in the Permutit. The softening continues as long as there is enough sodium left available for exchange. An interesting and economically valuable feature of Permutit is that it may, after use, be restored to its original efficiency simply by soaking it in common brine. The calcium and magnesium are thrown off, and the sodium from the brine takes their places. It is the reverse exchange and is called "regeneration." A Permutit plant is shown in Fig. 1.

For continuous 24-hr. operation the usual Permutit plant consists essentially of two softening filters in duplicate. Fig. 2 shows the layout, the names of the materials used and the names of the principal pipe connections. Frequently but one softening filter is used, a storage tank being provided to hold enough softened water to last until the Permutit

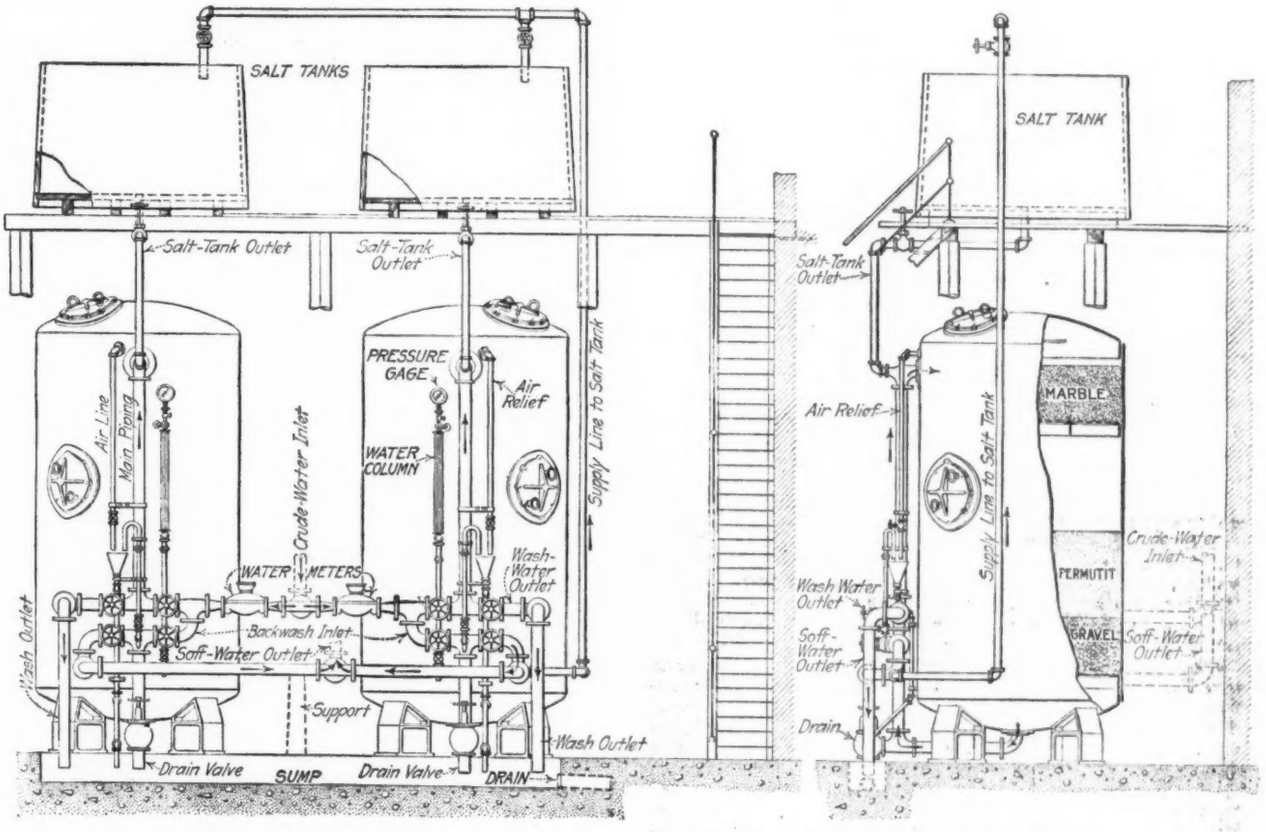


FIG. 2. SIDE AND END ELEVATIONS OF PERMUTIT WATER-SOFTENING SYSTEM

has been regenerated, which process requires 10 hr. after a 12-hr. run. When two filters are used, the substance in one is regenerated while that in the other is softening the water.

The Permutit is insoluble. For this reason a great excess of the reagent can be placed in the filter to drive the reaction to completion, producing a water of zero hardness without the possibility of the treated water showing the presence of the excess. Only an exchange of hardness for sodium is possible, and only as much sodium is given up by the Permutit as is required by this exchange. If the water is harder, it gives up more sodium; if it is softer, it gives up less. In this way the softened water is automatically kept free from the excess of chemicals and causticity. The exchange in a Permutit filter takes place in only a few minutes. Instead of a large tank holding 3 to 4 hr. supply, a small filter holding 5 to 10 min. supply is all that is required. The filters therefore lend themselves to small spaces and to places where floor space is an important consideration.

Referring to the part sectional view in Fig. 2, water flows into the top of the tank, filtering through the marble resting on a perforated plate; it then passes through the Permutit, through the gravel and out into the service lines. When the Permutit filter has produced its designed quantity of zero water, as may be seen by a water-meter attached, the regeneration follows. The Permutit is backwashed for a few minutes, the brine is admitted into the top of the filter, passing slowly through the Permutit bed for 10 hr. The salt is washed out after the regeneration, and the filter is ready for its next operating run. The cost of treatment, not including fixed charges, is that of the salt for regeneration. Common salt is used costing about $4 per ton of 2,000 lb., and from ¾ to 1 lb. of salt is required for each grain per gallon of hardness expressed as $CaCO_3$ for 1,000 U. S. gal. of water softened. The Permutit depreciates in quantity approximately 5 per cent. per year—in other words, a tank holding 200 lb. would have to have but 4 lb. added yearly.

Charles H. Bromley, instructor to the association, inquired: "As the calcium and magnesium are converted into sodium salts, what effect would this have on the tendency to foam?" The speaker stated that there were many factors which influence the tendency to foam. The design of the boiler, the vertical velocity at which the steam is generated, and the presence of suspended matter are the prime factors. C. H. Koyl made tests in the spring of 1901 on the alkali waters of the Colorado Desert used by the Rio Grande Western Ry. and found that "beyond question under ordinary conditions of service, boiler foaming takes place only in the presence of particles of matter suspended in the water in the boiler." (See the "Railroad Gazette," June 13, 1902, p. 432.) With boilers using Permutit filtered water the boiler saline remains clear and the effect of the concentration can be controlled by judicious blowing-down.

Bonus and Penalty Clauses

By F. H. Low

On the evening of Jan. 7, Edward Henderson, a Detroit attorney, gave an interesting lecture before the members and friends of the Detroit Engineering Society on the subject of "Bonus and Penalty Clauses in Contracts."

Mr. Henderson surprised many of the engineers by announcing that from the standpoint of law the penalty clause might as well be left out of a contract, as for every evasion of right there is compensation. No stipulation of damages need be mentioned. If a penalty clause is in a contract it will not stand unless the damages are compensatory. If the court finds that the penalty is a fair measure of the damage sustained, there it stands, but if the penalty is greater than the damage sustained, then the court will decline to allow penalty. This information may come as a surprise to many who advocate or practice the purchasing of coal on specification and the use of bonus and penalty clauses in the contract.

A case was cited where the Supreme Court of Michigan discarded the penalty clause on the ground that compensation did not enter into consideration in stipulating the penalty. To sum up, penalty can only be a measure of damages. There is no relation between bonus and penalty.

The question of validity of bonuses has not been settled. They are valid if all are supported by legal consideration. The enforcement of a bonus depends upon whether it is a fair deal; that is, if it is a fair compensation to the contractor for the extra effort put forth in completing the contract or if it is a measure of value received by the owner.

The status of the bonus and penalty clauses in contracts from a legal standpoint is practically the same throughout the United States with the exception of Louisiana, where laws pertaining to contracts are still affected by an early Spanish law retained when the state was received into the Union.

Fitting the Turbine to the Job*

By W. J. A. London†

SYNOPSIS—A designer well known in the small-turbine field tells of many interesting applications of the small turbine of straight-expansion, mixed-pressure, bleeder and low-pressure types. Why centrifugal boiler-feed pumps are not used in plants of small and moderate sizes.

The lecture was devoted solely to the small turbine. Mr. London stated that in the early days of turbine development, many formed unfavorable impressions about that kind of prime mover because of the ambitions of overzealous salesman and the ignorance of the buyer. The buyer wanted to be uptodate, and of course he must have a turbine whether that type of engine was best fitted to the job or not. And the salesman, unfortunately, often would sell a turbine to such a purchaser when he, the salesman, knew that a reciprocating engine was better suited. There is still a very wide field for the reciprocating engine.

Speaking of efficiencies of jets, several illustrations (lantern slide) were used to show that inasmuch as a turbine nozzle was designed for a given pressure drop, the jet must drop the pressure that amount or bring about many eddy currents within the jet, cutting down the efficiency. Therefore, if the steam coming to the jets is throttled by the governor, its entrance pressure is changed and eddying occurs in the jet. To avoid this the steam should be shut off from one nozzle, then another, and another, as the load on the machine will allow. Explaining the relations of steam speeds to wheel or bucket speeds, Mr. London showed the usual diagrams; these relations he likened to the cutoff on a reciprocating engine.

Mr. London stated with much emphasis that often too much importance is attached to the water rate of a turbine. If the steam required for heating feed water or for industrial purposes is as great or greater than is furnished by the exhaust steam from units about the plant, the water rate of the small turbine is of little importance as the over-all efficiency of the plant is not unfavorably influenced.

In this connection Mr. London discussed the question of the comparative economy of heating with live steam and with exhaust, and showed that in the average factory or mill the engines used but a small portion—about 5 per cent.—of the heat in the coal for direct conversion into mechanical energy, the rest passing off into the exhaust. Therefore, Mr. London believes the reason that one so frequently hears it said that it takes less, or only as much, coal to heat with exhaust as with live steam is that it is not possible to test the performance of a mill plant within 5 per cent. of accuracy. How the effect of the water rate of the turbines on the over-all efficiency of the plant may be minimized was shown by quoting figures from tests of the plants of two battleships, one having straight turbines, the other using turbines with reduction gears. Considered individually, the straight turbine showed an efficiency of 25 per cent., while that with reduction gear showed 47 per cent.; but the difference between the over-all efficiency of the two plants was only 0.067 per cent., presumably in favor of the latter. Several views of turbine installations in paper mills and such plants, where considerable exhaust steam is used, were shown. One of the chief reasons why the turbine is favored over the reciprocating engines for such service, Mr. London claimed, is that the steam from the turbine does not contain oil, as does steam from the engines, consequently the calendar rolls, heating plates, etc., transmit heat more uniformly and more constantly, and they do not have to be taken out of service to be cleaned of the oil.

It is well known, the speaker said, that a reciprocating engine could not satisfactorily use vacuum higher than 24 to 25 in., while the gain per inch increases much more rapidly from 22 to 29 in. or higher than from zero vacuum to 22 in. The practice, therefore, of using a low-pressure turbine in connection with a reciprocating engine, when the load demands permit, should be encouraged. The engine should be run with the boiler pressure as initial pressure and 15 in. vacuum as terminal pressure, the exhaust steam at this pressure to enter the turbine, there to expand down into the highest economical vacuum. The ideal arrangement is then had. Mr. London emphasized the importance of considering the quality of the exhaust or low-pressure steam available for a low-pressure turbine, when it is thought of installing one. The guarantees of such machines are usually based on dry saturated steam at atmospheric pressure or a little above. A 300-hp. plant of this kind in a Connecticut mill is saving, according to a statement of the engineer, 43 per cent. of the coal formerly used by the reciprocating engine alone, based on equivalent load conditions. The bleeder turbine, Mr. London claimed, is being widely applied in mill work.

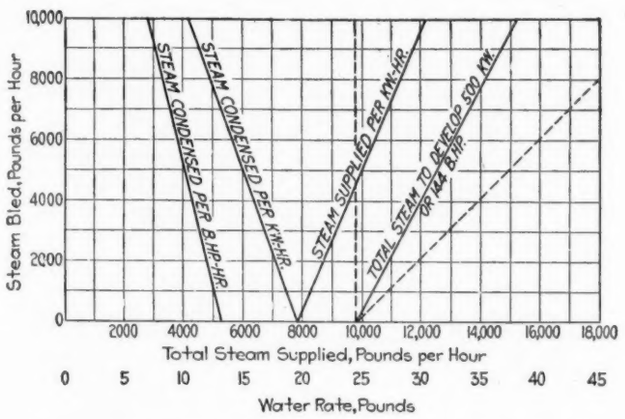


FIG. 1. FULL-LOAD PERFORMANCE CURVES, 500 KW. BLEEDER TURBINE

3,600 r.p.m., 175 lb. pressure, 125 deg. superheat, 27 in. vacuum. Bled at 7 lb. gage

Fig. 1 shows the full-load performance of a 500-kw. bleeder turbo-generator, the conditions being stated in the caption. Suppose it is desired to bleed from this machine 6,000 lb. of steam per hour at 7 lb. gage pressure; how much initial-pressure steam would be required, and what would be the water rate? On the "steam bled" line follow horizontally to the "total steam" curve; dropping vertically gives a trifle over 13,000 lb. per hr. and dropping vertically from the "steam supplied per kw.-hr." curve gives approximately 26¼ lb. per hr.

Fig. 2 shows the performance curves of a mixed-pressure-bleeder, geared turbine in a New England mill, the conditions being given in the caption. With no steam being bled and no low-pressure steam added, to develop 300 b.hp. will require 5,125 lb. of steam per hr. at the initial pressure of 100 lb. To develop the same power and bleed off 2,000 lb. of steam per hr. at 2 lb. pressure, 6,250 lb. of initial pressure steam will be needed. But if 2,000 lb. per hr. of exhaust steam from any source is available for use in the turbine, less than 4,000 lb. per hr. of initial pressure steam will be needed to develop 300 b.hp.

The speaker stated that too little attention was given to the alignment of the turbine and the driven machine. The

*From a recent lecture before the Brooklyn Engineers Club.

†Formerly chief engineer of the Terry Steam Turbine Co.; now with the Sterling Blower Co., Hartford, Conn.

so-called flexible coupling is not really flexible at the high speeds at which small turbines run, and it is designed to allow for only a few thousandths misalignment. Greater care should be taken by erectors of turbine-driven sets. Another matter of importance is the piping to and from the turbine. With reciprocating engines the weight of the engine to the sizes of pipe connected to it is much greater than with the turbine, consequently the lighter turbine could not so well withstand the thrust of pipe not put up with all expansion possibilities provided for.

"How often," asked Mr. London, "before the advent of the turbine did purchasers ask for guarantees as to water rate of reciprocating feed pumps and other small auxiliary apparatus? Very rarely; few ever thought about it. But now most buyers want a guarantee with turbines, however small."

The speaker was inclined to frown upon this practice, but admitted that it tended to make builders strive hard for the best results. He said small turbines could be made to run more economically than is now done, but the purchaser would not be willing to pay for the advantage. He explained that the water rate of a turbine decreases as the square root of the wheel and that the cost varies approximately as the diameter of the wheel.

During the discussion an operating man criticized the builders and designing engineers, not of turbines alone, but of other more or less new apparatus, for turning over to them

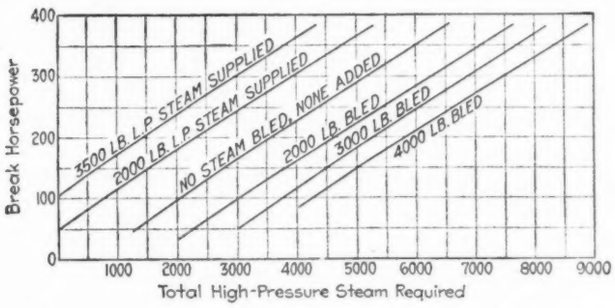


FIG. 2. PERFORMANCE CURVES, MIXED-PRESSURE BLEEDER TURBINE

200 kw., 100 lb. pressure, 27 in. vacuum. Low-pressure steam supplied at 2 lb. gage

equipment of which they, the operators, knew little, expecting them to get maximum results without adequately instructing them. In reply Mr. London said that that was indeed the situation and he deeply regretted it, but pleaded that it was most difficult to meet. His company, he stated, sends instruction books with all machines. Formerly it sent the books to the offices of the purchasers, but found that seldom did they reach the engineers for whom they were intended. Now two books are sent, one to the engineer in care of the office, and the other is wired to the machine.

Asked why turbine-driven centrifugal pumps were not used in plants of moderate and small sizes, Mr. London explained that below 100 to 150 gal. per min. a centrifugal pump to force against boiler pressure was not efficient when the water was around 200 deg. Troubles arise from the formation of vapor; the water passages are very restricted, and the clearances are proportionally great. When the water is cold, as when economizers but no feed-water heaters are used, as is so common abroad, small centrifugal pumps for boiler feed are successful.

Battery vs. Magneto Ignition*

By Frank Conrad

The ignition mechanism on the early automobile engines was copied from the system as used on stationary engines of that day. This was the so-called make-and-break system, in which an electric circuit was mechanically closed and opened through contact points placed inside the cylinder. The electric circuit usually consisted of a simple reactance coil in series with a few cells of primary battery. On separation of the contacts the inductive discharge from the coil produced a spark which ignited the charge in the cylinder. Under limited conditions this system leaves little to be desired. The spark is very hot, and if the mechanical part is well made, its operation is practically perfect.

The next scheme to be proposed was the jump-spark, or high-tension, system, which has the advantage of no working parts in the combustion space and therefore the parts are mechanically much simpler than the low-tension system. This system had the apparent disadvantage of giving a much weaker spark, and owing to the high voltage this spark might be further weakened by leakage. However, the modern high-speed gasoline engine would be impracticable with make-and-break ignition, although for the slow-speed stationary engine the low-tension system has held its own.

In the high-tension system the mechanism connected with the sparking points has been simple and the problem of insulation has been solved satisfactorily. It is therefore upon the mechanism that furnishes the high-tension current that attention is now centered. The first and most obvious solution was to use an ordinary vibrating-contact induction coil, the primary circuit of which was supplied from a primary battery and in the secondary circuit of which was induced a voltage sufficient to jump the space between the electrodes in the cylinder, these electrodes and their mounting forming the now well-known spark plug. The primary circuit of the induction coil was controlled by a contact device that served to close this circuit at the proper instant. The shortcomings of this system were mainly in the battery, and to obtain a reasonable life from the type of batteries available for this service, it was necessary to reduce the energy consumption to the minimum that would give satisfactory ignition. To overcome this defect, designers turned their attention to the matter of supplying this energy from a mechanical generator that would obtain its power from the gasoline engine.

IGNITION BY SINGLE INITIAL SPARK

As a simple alternating-current generator that gave a comparatively low frequency was used, it was found necessary to abandon the magnetically operated vibrator and substitute a mechanically operated one that would open and close the primary circuit of the induction coil at definite points on the voltage wave induced in the windings of the generator armature. This gave but one spark in the cylinder instead of the series of sparks induced by the vibrating coil. As it is necessary to obtain proper timing of the explosion so that the first spark may ignite the mixture, the succeeding sparks are superfluous, although it is possible that should the first spark, owing to unfavorable conditions, fail to ignite the mixture, a succeeding spark may do so. This condition can be practically overcome by supplying more energy to the single initial spark, which is permissible when this energy is generated by a mechanical device.

As a generator with permanent magnet fields gives the simplest arrangement and has the advantage of overcoming the time element necessary for any electromagnet field to be built up, the permanent type is universally used and the name "magneto" has by usage been taken to cover generating and spark-producing mechanism as a whole.

The advent of electric lighting, and later of electric starting of the gasoline engine, produced demands for electric energy on the automobile that could be met only by the use of a much more efficient type of generator than that which served for the supply of ignition energy. As it is necessary to have power when the engine is not running, a storage battery is required. This condition is being met by the variable-speed battery-charging generators now on the market. In view of this, the first impulse would be to go back to the original vibrating-coil system with its primary battery energy supplied from the lighting and starting system instead. This system, however, has certain disadvantages that have been in large measure corrected in the development of the magneto-generator, the principal ones being the time which elapses between the closing of the primary circuit and the production of the spark at the plug and the limitation which the vibrating contact mechanism places on the amount of energy it is possible to deliver to the spark plug. As this time is constant and independent of engine speed, it is obvious that the spark would occur progressively later as the engine speed increased. To overcome these defects it has been necessary to design a mechanism in which the primary contact points are operated mechanically, the same as in the case of the magneto. As the spark is produced at the opening of these contacts and this opening occurs at a definite angular position of the engine crankshaft, the spark is not retarded as the speed increases, thereby necessitating only the amount of angular advance required for the complete combustion of the exploding charge.

ENERGY CONDITIONS IN BATTERY SYSTEM

In the battery system the total energy to be supplied to the spark plug is delivered through the primary winding of the induction coil and stored as magnetic energy in the magnetic circuit of this coil. On opening the primary circuit this energy, minus the incidental losses, is delivered through the secondary winding to the spark plug. An oscillograph curve of the current in the spark-plug circuit

*From a paper presented at the annual meeting of the Society of Automobile Engineers, New York, Jan. 6, 1916.

shows that this current rises instantaneously to a definite value, from which value it gradually falls off to zero. The amount to which the current rises is determined by the value of the primary current and ratio of primary to secondary turns, while the time required for this current to fall to zero is determined by the energy stored in the magnetic circuit of the induction coil and by the resistance of the secondary circuit.

In the magneto the initial-current value through the spark plug is, as in the coil, operated from a battery, determined by the primary current and ratio of turns. Its subsequent value, however, may be modified by the fact that energy can be delivered directly to this secondary through the mechanical motion of the generator armature itself. The time required for the current in the spark-plug circuit to reach zero may therefore be prolonged over that which would be possible in the case of the simple induction-coil system. So far as performing its function of igniting the explosion charge is concerned, this prolonged spark can be of no value as, to properly develop the power in the cylinder, the combustion of the charge which is started at the spark-plug points must take place through the whole volume of charge in an extremely limited time as compared to one complete engine cycle. Therefore, no increase of power could be obtained by maintaining the spark at the spark-plug points after the mixture in the vicinity of these points has been burned. This effect of prolonging the duration of spark may be very deceptive in comparing by observation the relative intensities of the spark produced by different systems. Thus a greatly prolonged spark of comparatively low current value may appear much hotter than one of short duration but higher current value, although the latter would be the most efficient igniting spark.

LIMITATIONS IN MAGNETO VOLTAGE

A further distinction between magneto and battery ignition lies in the limitations on possible secondary voltage it is practical to generate in the magneto equipment, especially at the lower engine speeds. In the battery system it is possible to wind the secondary coil for any required voltage. In the magneto there are limitations of design, due particularly to the limited space in which it is possible to place a secondary winding and the difficulty of obtaining clearances necessary for effective insulation. This condition can be observed by noting the size of the magneto required to give efficient ignition when the jump-spark system is used on the comparatively slow-speed high-compression stationary engine.

Largest Direct-Current Motor

A 15,000-hp. direct-current motor and two 8,000-hp. motor outfits will form part of the electrical equipment which the Westinghouse Electric and Manufacturing Co. is building for the addition to the plant of the Inland Steel Co. at Indiana Harbor, Ind.

The 15,000-hp. unit, which is the largest of its kind, will drive a 40-in. reversing blooming mill and will receive its power and be controlled from a flywheel motor-generator set. By this means the power taken from the line will be equalized to practically a constant load. The rest of the equipment will include two 5,000-kw. 25-cycle 2,400-volt turbo-generators and two 1,000-kw. synchronous motor-generator sets.

ENGINEERING AFFAIRS

The Association of Iron and Steel Electrical Engineers will hold its 1916 convention in Chicago, Ill., Sept. 18 to 22, inclusive.

Government Safety-First Exhibit—There will be held in Washington, D. C., Feb. 21-26, a safety-first exhibit in which all the Government departments are taking an active part. This exhibit will take on a national aspect, as manufacturers and operators from all over the country are invited to be present, in order that they may see what the Government of the United States is doing in safety-first work. Secretary of the Interior Lane has sent a letter to the governor of each state, inviting him to send a delegate and asking that the chief mine inspector, a representative of the industrial commission, or of other agencies engaged in compiling statistics relating to the various mineral industries, also attend the exhibition. All interested persons are invited to visit the safety-first exhibit and attend the conference of state mine inspectors, which will be held at the office of the Bureau of Mines, Feb. 24.

Recent Court Decisions

Digested by A. L. H. STREET

Aspects of Boiler Explosions—The Iowa Supreme Court notes that there is an important distinction to be drawn on the question of liability for injury to, or death of, an employee resulting from explosion of a defectively designed boiler, according to whether the defendant employer purchased a standard type of boiler from a reputable manufacturer or had a part in designing or constructing the boiler in question. The decision was handed down in a case involving the responsibility of a railway company for the death of an engineer caused by the explosion of a locomotive boiler, but the same principle would govern liability for a stationary boiler accident. The court intimates that when an employer goes into the open market and purchases a standard type of engine or boiler from a reliable manufacturer without knowledge of any defects in it, either in design or construction, there is no liability on his part for an explosion resulting from such a defect, but it is held that where the employer or his engineers design an engine or boiler or approve the design, there is the same duty to see that it is reasonably safe as where it is both designed and constructed in the employer's shops. Incidentally, the court decided that one shown to have familiarity with boiler construction is qualified to give expert testimony as to the cause of an explosion, the weight of his evidence to be determined by the jury in the light of the extent of his experience. (Kirby vs. C., R. I. & P. Ry. Co., 155 "Northwestern Reporter," 343.)

Enjoining Dam Extensions—The owner of a dam may be enjoined from flooding upstream lands by the use of newly constructed flashboards at certain seasons of the year, although the injunction may cause greater injury to the use of the dam for power purposes than the flooding would cause to the complaining landowner, holds the Pennsylvania Supreme Court in the case of Woelpper vs. Pennsylvania Water and Power Co., 95 "Atlantic Reporter," 717. It was further decided in the same case that the fact that the defendant company had expended considerable money to construct collapsible flashboards on the dam before the injunction suit was brought did not preclude the plaintiff from maintaining the suit; there being nothing to show that he knew of such preparations and by withholding objection for an unreasonably long time apparently acquiesced in the proposed improvement.

Stationary Engine as "Fixture"—One who buys real estate comprising an industrial plant of which a steam-power plant is an essential part takes good title to a stationary engine constituting a permanent part of the plant and affixed to the building, if he has no actual knowledge of the existence of a chattel mortgage in favor of a third person covering the engine, although that mortgage may be recorded as a chattel mortgage. So holds the Texas Court of Civil Appeals in the recent case of Phillips vs. Newsome, 179 "Southwestern Reporter," 1123. The court recognizes the right of the parties to a mortgage on a stationary engine to agree between themselves that the engine shall remain personal property, although affixed to real estate, but holds that a third person who buys the real estate is entitled, in the absence of knowledge to the contrary and in the absence of record of the mortgage on the real-estate records of the county, to assume that the engine is an unincumbered part of the land.

Test of Equipment by Buyer—Under a contract for sale of soot blowers, entitling the buyer to reject them if they proved unsatisfactory after six months' trial, the Kentucky Court of Appeals holds that the buyer could not excuse rejection of the equipment on the ground that similar blowers had proved unsatisfactory to other buyers and that he, to save useless expense of installation treated the blowers as unsatisfactory. (Bayer Steam Soot Blower Co. vs. Louisville Trust Co., 179 "Southwestern Reporter," 1034.) The court said:

To determine the question of satisfaction, the contract plainly provides for a trial by the purchaser. The case is one where the purchaser must act in good faith. He should make the test required by the contract, and after fairly and candidly investigating and considering the matter, reach a genuine conclusion. To permit the purchaser to rely upon tests made by others similarly situated would not only do violence to the terms of the contract, but would inject into the case elements of confusion and uncertainty which the parties did not contemplate. Dissatisfaction with the blower system by others might be due to caprice or to improper installation or operation, and all these questions would have to be taken into consideration in determining whether another purchaser was justified in refusing to pay for the articles because he had found them unsatisfactory.

OBITUARY

B. C. Wilson, formerly chief engineer with the Atlas Portland Cement Co., Northampton, Penn., died early Sunday, Jan. 23. Mr. Wilson was with the engineering department of the Brooklyn Rapid Transit Co. at the time of his death.

PERSONALS

James Sayre, chief engineer, power station of the Trenton & Mercer County Traction Co., Trenton, N. J., has resigned, effective Feb. 1. He will be succeeded by George Anthony.

Harry R. Westcott has opened an office in the Chamber of Commerce Building, New Haven, Conn., for a general engineering practice to investigate, design and supervise the erection and operation of power stations, mills, electrical installations, etc., and to do all engineering work connected with industrial and power projects. Mr. Westcott was originally with a firm of consulting engineers; then served as mechanical engineer with a large textile combine; later was plant engineer with one of the largest manufacturers of rubber footwear; and recently has been superintendent of construction for the United Illuminating Co., of New Haven, making extensive improvements in its plants, and is still retained by that company as ts consulting engineer.

NEW PUBLICATIONS

THE W-PVT CHART. By M. R. Wolfard and C. K. Carpenter. Published by John Wiley & Sons, New York, 1915. Size, 24x38 in. Price, 50c. net.

This chart forms part of the authors' complete edition of "Exponential Computation Charts for Engineers," which will be published shortly. It is plotted on logarithmic paper and affords a ready means of finding the resulting temperature or work done by any gas following the "PV^n = constant" law (for any value of n) between any desired pressure limits or for any ratio of expansion. The pressure, volume and temperature relations are given in both English and metric units. Besides, there are a number of other conversions on the chart, such as the relation between inches of mercury or head of water and pounds per square inch; the areas, circumferences and diameters of circles; the cube, cube root and the $^3/_2$ or $^5/_2$ power or root of any number.

CONCRETE PILE STANDARDS. By Hunley Abbott. Published by Hunley Abbott, New York. Paper, 9x12 in.; 59 pages. Price, 50c.

This is a book of drawings, specifications and other data prepared for the assistance and convenience of engineers and others who prepare specifications and plans for concrete pile foundations. The work touches on each step in the design of such foundations and contains standard details of reinforced-concrete pile caps; specifications for different types of concrete piles; comparison of costs of concrete and wooden piles under various soil conditions; theory of pile support, and a detailed description and drawing showing the method of testing a concrete pile. The use of concrete piles is comparatively new in this country, and the author has presented data and valuable suggestions founded on practical experience.

THE GASOLINE AUTOMOBILE. By G. W. Hobbs and B. G. Elliott. Published by the McGraw-Hill Book Co., Inc., New York, 1915. Size, 6x9 in.; 259 pages; illustrated. Price, $2.

Considering the rapid advance in automobile practice during the past few years, books on this subject soon become out of date. The present book deals with practice up to the latter part of 1915 and is both descriptive and instructive in character; that is, it describes the essential features of the latest cars, the standard ignition, starting and lighting systems, and different makes of carburetors, and gives directions for the proper care, operation and adjustments of the car. The chapter on "Troubles and Remedies" should prove helpful. The text is based on an extension course of the University of Wisconsin and is intended primarily for the automobile owner or driver, affording him an opportunity to become more familiar with his car and aiding him in maintaining it so as to secure the best service at the least expense. For this purpose it is one of the best books the reviewer has seen.

DIESEL ENGINES. By A. H. Goldingham. Published by Spon & Chamberlin, New York, 1915. Size, 5x9 in.; 206 pages; illustrated. Price, $3.

Few books have been written dealing with the Diesel engine exclusively, and authoritative information on the subject is largely scattered through the files of technical publications and proceedings of engineering societies, which makes the present book especially welcome. It is felt that the author might advantageously have made the work more comprehensive, although in a comparatively small space he has covered much ground and dealt with the representative makes of both marine and stationary Diesels. The text is more than descriptive for it contains a chapter on details of construction, including many empirical formulas, and another chapter on operation, which should prove especially helpful to the operating man. It represents a general survey of present Diesel-engine practice, meeting the requirements of the operating man and the practicing engineer who may be called upon to recommend and prepare specifications for a Diesel-engine installation; while perhaps incomplete as to the needs of the designer, it will nevertheless afford him a handy reference as to the principal features of various makes.

Classified Ads

Positions Wanted
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RATES: Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance. Other advertisements, 5 cents a word, minimum charge $1.00. Count 4 words for blind address care of our New York or Chicago offices. Advertisements for bids $3.60 an inch.

ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

Note: Copy for the issue of Feb. 15 is required one day earlier than noted above.

POSITIONS OPEN

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

AN ASSISTANT ENGINEER wanted in large power plant near Philadelphia; must be able to prove experience in operation of the leading turbines, Corliss engines and boilers; must have machine-shop experience and be willing to work. P694—Power.

YOUNG TECHNICAL GRADUATE wanted to handle advertising and catalog work in conjunction with general sales work for steam turbine company in New England; salary about $1,200. P700—Power.

MAN wanted to take charge of erection and maintenance of machines and power equipment in Tannery located in small town near city; permanent position for the right man; in answering give full particulars regarding age, experience and salary considered. P696—Power.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

BY ENGINEER with license; have had 10 years' experience; am temperate, capable and reliable; can furnish best of reference. E. Murdock, P. O. Box 5, Bainbridge, Ohio.

YOUNG MAN desires a start; handy and willing; a graduate of the Fireman's School U. S. Army, and an I. C. S. student; handy in boiler and engine room and with their auxiliaries. PW692—Power.

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

ENGINEER—Technical graduate, two years on general electric test, at present in charge of power and mechanical department for coal mining company, desires position in the West offering opportunities for advancement. PW684—Power.

SUPERINTENDENT OR CHIEF ENGINEER of 800-hp. plant (or larger preferred); ambitious young man, thoroughly experienced in installation, operation and maintenance of power plants; technical education, and executive ability; can produce results; Central States. PW697—Power, Chicago.

YOUNG MARRIED MAN with ten years as superintendent of electric-light and water plants, with five years at present place, desires similar position or position as engineer in moderate-sized plant; fully experienced in everything electrical, steam, gas and water; will be at liberty about Mar. 1; best of references from past and present employers. PW698—Power, Chicago.

MARINE ENGINEER, licensed as chief engineer of ocean vessels, now serving as first assistant on a steamship, familiar with the operation of large units, refrigerating machinery, oil fuel, construction of machinery, desires position ashore as chief engineer of small plant or assistant in large one; location immaterial; would like correspondence regarding position open about July 1. PW699—Power, Chicago.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

AGENTS AND SALESMEN

AGENTS to handle boiler-efficiency device; liberal commission and full coöperation. W686—Power, Chicago.

AGENTS wanted to handle a new patented grate bar on commission; state experience, location, how long established. W685—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

A MAN wanted successful in the selling of power-plant specialties to handle an old established line on a commission basis. Address with complete details as to experience, references, etc. W695—Power, Chicago.

AGENTS on commission to sell our Shaking Grates; we will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio.

AGENTS on commission to sell the new and successful Duplex return steam trap. Join a rapidly growing organization. Address American Duplex Steam Trap Co., 413 Moffat Block, Detroit, Mich.

MISCELLANEOUS

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

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Second Hand Equipment

Rates: Less than 4 insertions 75 cents per line—4 to 11 insertions 70 cents per line—12 or more insertions 65 cents per line

Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbreviated in most of these items. Complete names and addresses are as follows:

MANHATTAN Rubber Mfg. Co., Passaic, N. J.—All equipment advertised may be seen in daily operation at the company's plant. Delivery Mar. 15, 1916, f.o.b. D., L. & W. R.R., Passaic.

NEW RIVER CO., The, MacDonald, W. Va.

WHEELING Electric Co., 51—16th St., Wheeling, W. Va.—No reasonable offer will be refused for any of the equipment advertised.

BOILERS

2 Class E-7 Sterling water tube, 150 hp. each, 1,500 sq.ft. heating surface, 3¼" tubes, pressure allowed, 150 lb.; 2 Erie City return tubular 18' long, 72" dia., 70 4" flues, 150 hp.—WHEELING.

ENGINES, STEAM

Horizontal and Vertical, capacities 6 to 320 H.P. All good makes.—NEW RIVER.

1—14"x36" Allis-Chalmers Corliss, 1890 type, R.H., fine condition.—L. F. Seyfert's Sons, Inc., 437 N. 3rd St., Phila., Pa.

1 Ball 10"x12" auto. wheel governor, 280 r.p.m., belt wheel, 5' dia., 8" face; 1 Ball 14"x18"; 1 Russell 14"x18", single valve, side crank; 1 Russell 20"x27", 4-valve, side crank; 1 Russell 15"x20", single valve, side crank; 1 Buckeye 14"x16", side crank, outboard bearing pulley 14"x72"; 7 Erie City 16"x18", side crank, outboard bearing pulley 20"x84"; 1 Hamilton Corliss non-condensing single engine 22"x36", left hand, 5 wheel, 12" in diam., 40" face.—WHEELING.

Fitchburg left hand, horizontal, tandem compound; cylinders 17" and 28" dia., 36" stroke, 120 r.p.m., heavy tangye frame; double ported piston valves; flywheel 14' dia., 24" face, with governor and outboard bearing, $3,000.—MANHATTAN.

One 500 h.p. Bates Corliss Cross Compound Condensing Engine and one 400 h.p. Buckeye Tandem Compound Horizontal Engine. Both engines in first-class condition and must be sold at once.—Wabash Portland Cement Co., Ford Bldg., Detroit, Mich.

125 H. P. Corliss Engine, Worthington Condenser, 56 ft. 4 15/16" shafting, pulleys, couplings and boxes, also two 40" clutches, Cresson's equipment, must be sold at once to make room for other equipment. Our present requirements have outgrown the above power plant which has only seen 5 years' service. The above guaranteed in excellent condition. Second hand dealers or Factory owners in need of more power will do well to look into this bargain.—J. B. Martin Co., Norwich, Conn..

American Ball Engine 160 HP. 16"x14", 250 R.P.M. with belt wheel 72"x15", new, was never set on foundation.—F. S. 693—Power.

GENERATING UNITS

Direct current, 250-500 V., cap. up to 250 KW.—NEW RIVER.

One 220 KW., A.C., 60-cycle, 2,200-volt, two-phase generator, direct connected to 200-r.p.m. Buckeye engine, with transformers for supplying 2,200 volts, 3-phase, complete with barometric condenser, motor-driven condenser pump, switchboard instruments and instrument transformers. Complete details upon application to WISCONSIN GAS & ELECTRIC CO., Racine, Wis.

Engine and Generator—One Hamilton 19x36x42" horiz. tandem compound Corliss engine, shop No. 2649 L.P., with 14x16" c.-i. flywheel; mfd. by Hooven, Owens, Rentschler Co., Hamilton, Ohio, D.C. to Westinghouse 580-kw. generator, 440-v., 761 amp., 3-phase, 25-cycle, 107 r.p.m.; No. 453,419; mfd. by Westinghouse Electric & Mfg. Co., Pittsburgh, Pa. Equipment has been in operation 5 yr. and can be seen at our Cedar Rapids mill. For price and full information address National Oats Co., St. Louis, Mo.

GENERATORS

1 Warren induction type generator, A-18 type, 85 kw., No. 744, 2,300 V., 60-cycle, 720 r.p.m., single phase, exciter bolted on generator base, belt driven; also one A-20 type, 110 kw. 2,200 V., 60-cycle, single phase, 720 r.p.m., exciter bolted on generator base, belted to engine shaft.—WHEELING.

Sprague belted, D.C., type S, 150 kw., 120-125-V., 1,200 amp., 550 r.p.m., with base, slide rails and voltage regulator, $800.—MANHATTAN.

HEATERS, FEED WATER

1—750-hp. Webster vacuum; 1 Stillwell Bierce No. 7470.—WHEELING.

MOTORS

1 G. E. D.C. shunt wound motor, type C. E., Class 4, 10 hp., form B, 800 r.p.m., 500 V., No. 10,403.—WHEELING.

PIPE AND FITTINGS

Pipe and fittings, screwed & flanged, 7 to 18".—NEW RIVER.

PUMPS

High head, general service and boiler feed.—NEW RIVER.

1—7½ in. x 4½ in. x 10 in. Laidlaw-Dunn-Gordon duplex outside packed boiler feed; 1—6"x4"x6" Fairbanks-Morse boiler feed; 1—6"x4"x6" Snider-Hughes boiler feed.—WHEELING.